UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Region
7600 Sand Point Way N.E., Bldg. 1
Seattle, WA 98115

Refer to:
1999/01873

October 8, 2003

Mr. Lawrence Evans
U.S. Army Corps of Engineers, Portland District
ATTN: Mary Headley
P.O. Box 2946
Portland, OR 97208-2946

Re: Endangered Species Act Section 7 Formal Consultation and Magnuson-Stevens Act Essential Fish Habitat Consultation on the Proposed Gorge Harbor Marina in Bingen, Washington (Corps No. 199701333)

Dear Mr. Evans:

Enclosed is a biological opinion (Opinion) prepared by the National Marine Fisheries Service (NOAA Fisheries) pursuant to section 7 of the Endangered Species Act (ESA) on the effects of issuing a permit under section 10 of the Rivers and Harbors Act and section 404 of the Clean Water Act to authorize construction of the proposed Gorge Harbor Marina in Bingen, Washington. NOAA Fisheries concludes in this Opinion that the proposed action is not likely to jeopardize the continued existence of Snake River (SR) fall-run chinook salmon (*Oncorhynchus tshawytscha*), SR spring/summer-run chinook salmon, Upper Columbia River (UCR) spring chinook salmon, SR sockeye salmon (*O. nerka*), SR steelhead (*O. mykiss*), UCR steelhead, Middle Columbia River steelhead, and Lower Columbia River steelhead, or destroy or adversely modify designated critical habitat for SR chinook and sockeye salmon. As required by section 7 of the ESA, we include reasonable and prudent measures with non-discretionary terms and conditions that are necessary to minimize the potential for incidental take associated with this action.

This document also serves as consultation on essential fish habitat (EFH) for chinook and coho salmon pursuant to section 305(b) of the Magnuson-Stevens Fishery Conservation and Management Act and its implementing regulations at 50 CFR Part 600.

A complete administrative record of this consultation is on file at the Oregon Habitat Branch Office.

Please direct any questions regarding this consultation to Ben Meyer of my staff in the Oregon Habitat Branch at 503.231.2307.

Sincerely,

for Michael R Crouse

D. Robert Lohn
Regional Administrator

Endangered Species Act - Section 7 Consultation
Biological Opinion

&

Magnuson-Stevens Fishery Conservation and Management Act
Essential Fish Habitat Consultation

Gorge Harbor Marina in Bingen, Washington
(Corps No. 199701333)

Agency: U.S. Army Corps of Engineers

Consultation Conducted By: National Marine Fisheries Service, Northwest Region

Date Issued: October 8, 2003

Issued by: for Michael R Crouse

D. Robert Lohn
Regional Administrator

Refer to: **1999/01873**

TABLE OF CONTENTS

1. INTRODUCTION

1.1 Background

On January 12, 1999, the U.S. Army Corps of Engineers (COE) sent a letter to Elizabeth Gaar, of the National Marine Fisheries Service (NOAA Fisheries), requesting concurrence with their finding that authorizing construction of a marina in the Columbia River (river mile 172) at Bingen, Washington, was "not likely to adversely affect" (NLAA) Endangered Species Act (ESA) listed and proposed salmonids. Included with the letter was a Biological Evaluation (BE).

NOAA Fisheries originally provided comments to a COE Public Notice for this permit in February, 1999. Because of concerns for potential increases in predation associated with the project as designed, NOAA Fisheries recommended that the requested permit be denied. NOAA Fisheries also recommended denial of this proposal due to potential cumulative effects of predation resulting from in-water structures.

On July 1, 1999, NOAA Fisheries issued a draft biological opinion to the COE indicating that it was NOAA Fisheries' opinion that the project as proposed was likely to jeopardize the continued existence of the species under consideration. After numerous meetings and discussions, the applicant submitted revised plans for the project on February 24, 2003. A final meeting was held on March 19, 2003 to finalize the description of the project and final drawings and plans were submitted on September 2, 2003.

The objective of this biological opinion (Opinion) is to determine whether issuance of the proposed permit as revised is likely to jeopardize the continued existence of salmonid species listed in Table 1, or result in the destruction or adverse modification of listed critical habitat.

1.2 Proposed Action

The proposed action is issuance of a COE permit (199701333) for the three-phase construction of a marina, consisting of 195 boat slips (uncovered and covered), 45 combination boathouses (covered moorage with residences overhead), and a fuel dock and pump out station (S1 dock) in a backwater area of the Columbia River at Bingen, Washington. A ships store and repair and maintenance facility would eventually be constructed on uplands beside the docks.

Phase 1 would consist of two docks. The S1 dock (8 feet by 196 feet) would support 12 uncovered slips, a combination boat house, a fueling facility and a pump out station at the end of the dock. Every 20-foot dock section would be separated by a 2-foot by 8-foot grate. The second dock (M1) would have 18 uncovered slips and 17 combination boathouses. The 400-foot dock would be constructed of 8-foot by 10-foot floats separated by a 2-foot by 8-foot grate. Finger piers for boat slips on S1 would be 4.5 feet wide.

Phase 2 would consist of two more docks. One (M2) would be 822 feet long by 8 feet wide, with 21 uncovered slips and 20 combination boathouses. The second dock (S2) would have 86 boat slips (uncovered and covered) with two main walkways. Both docks would be constructed of 8-foot by 10-foot floats separated by a 2-foot by 8-foot grate. Finger piers for boat slips on both docks would be 4.5 feet wide.

Phase 3 would consist of a fifth dock (S3) and an extension to S2. S3 (8 feet by 400 feet) would have 24 slips (uncovered and covered). The addition to S2 (8 feet by 400 feet) would add 34 slips (covered and uncovered), and eight combination boathouses. S3 and the addition to S2 would be constructed of 8-foot by 10-foot floats separated by a 2-foot by 8-foot grate. Finger piers for boat slips on both docks would be 4.5 feet wide.

Dock and piling installation would occur during the Washington Department of Fish and Wildlife work window of November 1 to February 28. All docks would be situated at least 50 feet offshore and in waters at least 10 feet deep at low pool elevation. Boathouses would be no more than 30 feet wide by 50 feet long. Opposite units on boathouse docks would be staggered to allow a more even distribution of light. To provide light under the structure, all boathouses would have: (1) A minimum of two solatubes, installed in the forward covered part of the structure; (2) a 6-foot by 35-foot clear or translucent side window; (3) a 14-foot by 14-foot clear or translucent garage door; and (4) white-painted boatwell interiors. Boathouses would be separated by at least 14-foot wide boat slips. All pilings for all docks will be made of steel.

Floating dockways would be constructed of materials to allow maximum light penetration. The applicant is proposing the use of translucent docks, if the engineering can be accomplished. Grated floats or concrete floats with light tubes will be used if the translucent decks are not feasible. Floats will be contained to avoid break up of flotation material.

In Phase 1, one fish counting device shall be placed under the darkest area of every 5th combination boathouse to monitor how fish presence may be affected by the structure. Two other devices shall be placed in areas not subject to significant shading. The devices will be monitored by a qualified fisheries biologist. If significant numbers of fish are detected, videos will be used to determine fish species. The results will be used to determine if further efforts are needed in future phases to dissuade predatory fish usage of the facility.

Shoreline plantings along the Columbia River will be conducted to mitigate for potential impacts from construction and operation of the facility. The applicant proposes to plant approximately 600 linear feet of riparian area along the Columbia River in the project area. Plantings would consist of native hardwood and coniferous trees.

On-shore parking may be located within the setback area near the top of the berm around the facility subject to Washington Department of Ecology approval.

Table 1. References for Additional Background on Listing Status/Critical Habitat/Protective Regulations/and Biological Information for the Listed Species Addressed in this Opinion

Species	Listing Status	Critical habitat	Protective Regulations	Biological Information/ Population Trends
SONC coho salmon	Threatened 02/18/97 62 FR 33038	05/05/99 64 FR 24049	07/18/1997 62 FR 38479	Weitkamp *et al.* 1995; *NOAA Fisheries* 1997a; Sandercock 1991; Nickelson *et al.* 1992
OC coho salmon	Threatened 08/10/98 63 FR 42587		07/10/00 65 FR 42422	Weitkamp *et al.* 1995; Nickelson *et al.* 1992; *NOAA Fisheries* 1997b; Sandercock 1991
SR fall-run chinook salmon	Threatened 04/22/92 57 FR 14653	12/28/93 58 FR 68543	07/22/1992 57 FR 14653	Waples *et al.* 1991b; Healey 1991; ODFW and WDFW 1998
SR spring/summer-run chinook salmon	Threatened 04/22/92 57 FR 14653	12/28/93 58 FR 68543 and 10/25/19 64 FR 57399	04/22/1992 57 FR 14653	Matthews and Waples 1991; Healey 1991; ODFW and WDFW 1998
LCR chinook salmon	Threatened 03/24/99 64 FR 14308		07/10/00 65 FR 42422	Myers *et al.*1998; Healey 1991; ODFW and WDFW 1998
UWR chinook salmon	Threatened 03/24/99 64 FR 14308		07/10/00 65 FR 42422	Myers *et al.*1998; Healey 1991; ODFW and WDFW 1998
UCR spring-run chinook salmon	Endangered 03/24/99 64 FR 14308		ESA prohibition on take applies	Myers *et al.*1998; Healey 1991; ODFW and WDFW 1998
CR chum salmon	Threatened 03/25/99 64 FR 14508		07/10/00 65 FR 42422	Johnson *et al.*1997; Salo 1991; ODFW and WDFW 1998
SR sockeye salmon	11/20/91 56 FR 58619 Endangered	12/28/93 58 FR 68543	ESA prohibition on take applies	Waples *et al.* 1991a; Burgner 1991; ODFW and WDFW 1998
UCR steelhead	08/18/97 62 FR 43937 Endangered		ESA prohibition on take applies	Busby *et al.* 1995; Busby *et al.* 1996; ODFW and WDFW 1998
SR Basin steelhead	08/18/97 62 FR 43937 Threatened		07/10/00 65 FR 42422	Busby *et al.* 1995; Busby *et al.* 1996; ODFW and WDFW 1998
LCR steelhead	03/19/98 63 FR 13347 Threatened		07/10/00 65 FR 42422	Busby *et al.* 1995; Busby *et al.* 1996; ODFW and WDFW 1998
UWR steelhead	03/25/99 64 FR 14517 Threatened		07/10/00 65 FR 42422	Busby *et al.* 1995; Busby *et al.* 1996; ODFW and WDFW 1998
MCR steelhead	03/25/99 64 FR 14517 Threatened		07/10/00 65 FR 42422	Busby *et al.* 1995; Busby *et al.* 1996; ODFW and WDFW 1998

2. ENDANGERED SPECIES ACT

2.1 Biological Opinion

2.1.1 Biological Information and Critical Habitat

Based on migratory timing, it is not likely that any adult and juvenile salmon or steelhead from listed or proposed species would be present during the normal in-water work period of November 1 to February 28. However, some listed salmonids may use the area for over-wintering habitat. To what extent the project area is used by over-wintering salmonids is unknown. Listed species may also use the area as a resting and feeding area during juvenile outmigration after construction is completed. The proposed action would occur within designated critical habitat for some of the species considered in this Opinion.

An action area is defined by ESA regulations (50 CFR Part 402) as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." The area affected by the proposed action is the excavated backwater area and the Columbia River within 300 feet upstream and downstream of the project site. This area serves as a rearing area for juvenile salmon and as migratory corridor for both adult and juvenile life stages of all listed species under consideration in this Opinion. Essential features of the area for the species are: (1) Substrate, (2) water quality, (3) water quantity, (4) water temperature, (5) water velocity, (6) cover/shelter, (7) food (juvenile only), (8) riparian vegetation, (9) space, and (10) safe passage conditions. The essential features this proposed project may affect are water quality resulting from construction activities, and water quality, food, and safe passage conditions as a result of the structures placed in the river.

References for further background on listing status, biological information and critical habitat elements can be found in Table 1.

2.1.2 Evaluating Proposed Actions

The standards for determining jeopardy are set forth in section 7(a)(2) of the ESA as defined by 50 CFR. Part 402 (the consultation regulations). NOAA Fisheries must determine whether the action is likely to jeopardize the listed species and/or whether the action is likely to destroy or adversely modify critical habitat. This analysis involves the initial steps of: (1) Defining the biological requirements of the listed species; and (2) evaluating the relevance of the environmental baseline to the species' current status.

Subsequently, NOAA Fisheries evaluates whether the action is likely to jeopardize the listed species by determining if the species can be expected to survive with an adequate potential for recovery. In making this determination, NOAA Fisheries must consider the estimated level of mortality attributable to: (1) Collective effects of the proposed or continuing action; (2) the environmental baseline; and (3) any cumulative effects. This evaluation must take into account measures for survival and recovery specific to the listed salmon's life stages that occur beyond the action area. If NOAA Fisheries finds that the action is likely to jeopardize, NOAA Fisheries must identify reasonable and prudent alternatives for the action.

Furthermore, NOAA Fisheries evaluates whether the action, directly or indirectly, is likely to destroy or adversely modify the listed species' critical habitat. NOAA Fisheries must determine whether habitat modifications appreciably diminish the value of critical habitat for both survival and recovery of the listed species. NOAA Fisheries identifies those effects of the action that impair the function of any essential element of critical habitat. NOAA Fisheries then considers whether such impairment appreciably diminishes the habitat's value for the species' survival and recovery. If NOAA Fisheries concludes that the action will adversely modify critical habitat, it must identify any reasonable and prudent alternatives available.

For the proposed action, NOAA Fisheries' jeopardy analysis considers direct or indirect mortality of fish attributable to the action. NOAA Fisheries' critical habitat analysis considers the extent to which the proposed action impairs the function of essential elements necessary for adult and juvenile migration of the listed UCR salmon under the existing environmental baseline.

2.1.3 Biological Requirements

The first step in the method NOAA Fisheries uses for applying the ESA standards of § 7 (a)(2) to listed salmon is to define the species' biological requirements that are most relevant to each consultation.

The relevant biological requirements are those necessary for the listed species to survive and recover to naturally-reproducing population levels, at which time protection under the ESA would become unnecessary. Adequate population levels must safeguard the genetic diversity of the listed stocks, enhance their capacity to adapt to various environmental conditions, and allow them to become self-sustaining in the natural environment.

For this consultation, the biological requirements are increased migration survival and improved habitat characteristics that function to support successful migration.

2.1.4 Environmental Baseline

Regulations implementing section 7 of the ESA (50 CFR 402.02) define the environmental baseline as the past and present impacts of all Federal, state, or private actions and other human activities in the action area. The environmental baseline also includes the anticipated impacts of all proposed Federal projects in the action area that have undergone section 7 consultation, and the impacts of state and private actions that are contemporaneous with the consultation in progress. The action area is defined in 50 CF. 402.02 to mean "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action".

The proposed action would occur within designated critical habitat for some of the listed ESUs considered in this Opinion. Essential elements of critical habitat for the listed ESUs are described section 2.1.1, above.

The most recent evaluation of the environmental baseline for the Columbia River is part of the NOAA Fisheries's Opinion for the Bonneville Power Administration's Habitat Improvement Program, issued in August, 2003 (refer to: 2003/00750). A detailed evaluation of the environmental baseline of the Columbia River basin can be found in this Opinion (NMFS 2003).

The quality and quantity of freshwater habitat in much of the Columbia River basin has declined dramatically in the last 150 years. Forestry, farming, grazing, road construction, hydropower system development, mining, and development have radically changed the historical habitat conditions of the basin. More than 2,500 streams, river segments, and lakes in the Northwest do not meet federally-approved, state, and/or Tribal water quality standards, and are now listed as water-quality-limited under section 303(d) of the Clean Water Act (CWA). Tributary water quality problems contribute to poor water quality when sediment and contaminants from the tributaries settle in mainstem reaches and the estuary. Most of the waterbodies in Oregon on the 303(d) list do not meet water quality standards for temperature. High water temperatures adversely affect salmonid metabolism, growth rate, and disease resistance, as well as the timing of adult migrations, fry emergence, and smoltification. Many factors can cause high stream temperatures, but they are primarily related to land-use practices rather than point-source discharges. Some common actions that cause high stream temperatures are the removal of trees or shrubs that directly shade streams, water withdrawals for irrigation or other purposes, and warm irrigation return flows. Loss of wetlands and increases in groundwater withdrawals contribute to lower base-stream flows that, in turn, contribute to temperature increases. Activities that create shallower streams also cause temperature increases.

Many waterways in the Columbia River basin fail to meet CWA and Safe Drinking Water Act (SDWA) water quality standards due to the presence of pesticides, heavy metals, dioxins and other pollutants. These pollutants originate from both point- (industrial and municipal waste) and nonpoint (agriculture, forestry, urban activities, *etc.*) sources. The types and amounts of compounds found in runoff are often correlated with land use patterns. Fertilizers and pesticides are found frequently in agricultural and urban settings, and nutrients are found in areas with human and animal waste. People contribute to chemical pollution in the basin, but natural and seasonal factors also influence pollution levels in various ways. Nutrient and pesticide concentrations vary considerably from season to season, as well as among regions with different geographic and hydrological conditions. Natural features, such as geology and soils, and land-management practices, such as storm water drains, tile drainage, and irrigation, can influence the movement of chemicals over both land and water. Salmon and steelhead require clean water and gravel for successful spawning, egg incubation, and fry emergence. Fine sediments clog the spaces between gravel and restrict the flow of oxygen-rich water to the incubating eggs. Pollutants, excess nutrients, low levels of dissolved oxygen, heavy metals, and changes in pH also directly affect the water quality for salmon and steelhead.

Water quantity problems are also a significant cause of habitat degradation and reduced fish production. Millions of acres in the Columbia River basin are irrigated. Although some of the water withdrawn from streams eventually returns as agricultural runoff or groundwater recharge, crops consume a large proportion of it. Withdrawals affect seasonal flow patterns by removing water from streams in the summer (mostly May through September) and restoring it to surface streams and groundwater in ways that are difficult to measure. Withdrawing water for irrigation, urban consumption, and other uses increases temperatures, smolt travel time, and sedimentation. Return water from irrigated fields can introduce nutrients and pesticides into streams and rivers. Deficiencies in water quantity have been a problem in the major production subbasins for some ESUs that have seen major agricultural development over the last century. Water withdrawals (primarily for irrigation) have lowered summer flows in nearly every stream in the basin and thereby profoundly decreased the amount and quality of rearing habitat. In fact, in 1993, fish and wildlife agency, Tribal, and conservation group experts estimated that 80% of 153 Oregon tributaries had low-flow problems, two-thirds of which were caused (at least in part) by irrigation withdrawals (OWRD 1993). The Northwest Power Planning Council (NWPPC 1992) found similar problems in many Idaho, Oregon, and Washington tributaries.

Blockages that stop downstream and upstream fish movement exist at many dams and barriers, whether they are for agricultural, hydropower, municipal/industrial, or flood control purposes. Culverts that are not designed for fish passage also block upstream migration. Being diverted into unscreened or inadequately screened water conveyances or turbines sometimes kills migrating fish. While many fish-passage improvements have been made in recent years, manmade structures continue to block migrations or kill fish throughout the basin.

On the landscape scale, human activities have affected the timing and amount of peak water runoff from rain and snowmelt. Forest and range management practices have changed vegetation types and density that, in turn, affect runoff timing and duration. Many riparian areas, floodplains, and wetlands that once stored water during periods of high runoff have been destroyed by development that paves over or compacts soil—thus increasing runoff and altering natural hydrograph patterns.

Land ownership has also played its part in the region's habitat and land-use changes. Federal lands, which compose 50% of the basin, are generally forested and situated in upstream portions of the watersheds. While there is substantial habitat degradation across all land ownerships, in general, habitat in many headwater stream sections is in better condition than in the largely non-federal lower portions of tributaries (Doppelt *et al.* 1993, Frissell 1993, Henjum *et al.* 1994, Quigley and Arbelbide 1997). In the past, valley bottoms were among the most productive fish habitats in the basin (Stanford and Ward 1992, Spence *et al.* 1996, ISG 1996). Today, agricultural and urban land development and water withdrawals have significantly altered the habitat for fish and wildlife in these valley bottoms. Streams in these areas typically have high water temperatures, sedimentation problems, low flows, simplified stream channels, and reduced riparian vegetation.

At the same time, some habitats were being destroyed by water withdrawals in the Columbia basin, water impoundments in other areas dramatically reduced habitat by inundating large amounts of spawning and rearing habitat and reducing migration corridors, for the most part, to a single channel. Floodplains have been reduced in size, off-channel habitat features have been lost or disconnected from the main channel, and the amount of large woody debris (large snags/log structures) in rivers has been reduced. Most of the remaining habitats are affected by flow fluctuations associated with reservoir management.

More than 50% of the original marshes and spruce swamps in the estuary have been converted to industrial, transportation, recreational, agricultural, or urban uses. More than 3,000 acres of intertidal marsh and spruce swamps have been converted by human use since 1948 (LCREP 1999). Many wetlands along the shore in the upper reaches of the estuary have been converted to industrial and agricultural lands after levees and dikes were constructed. Furthermore, water storage and release patterns from reservoirs upstream of the estuary have changed the seasonal pattern and volume of discharge. The peaks of spring/summer floods have been reduced and the amount of water discharged during winter has increased.

The project area is currently used as a recreational boat ramp with a small park and unoccupied industrial zoned land adjacent to a man-made backwater area. The interior of the backwater on the western side has been rip-rapped and has extensive blackberry growth.

Aquatic habitat in the project area consists primarily of fine and coarse-grained sands and silts. Some pockets of rubble, cobble and gravels may also be present. Listed fish species utilize the action area primarily as a migration corridor. Some rearing/feeding may occur.

2.1.5 Effects of Proposed Action

NOAA Fisheries believes that the proposed action may affect listed salmonids in the following ways:

1. Impacts resulting from construction activities.
2. Increased predation as a result of placement of in-water structures.
3. Other impacts resulting from placement of in-water structures.
4. Impacts resulting from changes to water quality.
5. Impacts resulting from associated boating activities.

These impacts are discussed below.

<u>Pile driving and pilings</u>
Pile driving may result in increased turbidity and decreased available substrate. The effects of suspended sediment and turbidity on fish reported in the literature range from beneficial to detrimental. Elevated total suspended solids (TSS) conditions have been reported to enhance cover conditions, reduce piscivorous fish/bird predation rates, and improve survival. Elevated TSS conditions have also been reported to cause physiological stress, reduce growth, and

adversely affect survival. Of key importance in considering the detrimental effects of TSS on fish are the frequency and the duration of the exposure, not just the TSS concentration.

Behavioral avoidance of turbid waters may be one of the most important effects of suspended sediments (DeVore *et al.* 1980, Birtwell *et al.* 1984, Scannell 1988). Salmonids have been observed to move laterally and downstream to avoid turbid plumes (Sigler *et al.* 1984, Lloyd 1987, Scannell 1988, Servizi and Martens 1991). Juvenile salmonids avoid streams that are chronically turbid, such as glacial streams or those disturbed by human activities, unless the fish need to traverse these streams along migration routes (Lloyd *et al.* 1987).

Fish that remain in turbid, or elevated TSS, waters experience a reduction in predation from piscivorous fish and birds (Gregory and Levings 1998). In systems with intense predation pressure, this provides a beneficial tradeoff (*e.g.*, enhanced survival) to the cost of potential physical effects (*e.g.*, reduced growth). Turbidity levels of about 23 nephalometric turbidity units (NTU) have been found to minimize bird and fish predation risks (Gregory 1993). Exposure duration is a critical determinant of the occurrence and magnitude of physical or behavioral effects (Newcombe and MacDonald 1991). Salmonids have evolved in systems that periodically experience short-term pulses (days to weeks) of high suspended sediment loads, often associated with flood events, and are adapted to such high pulse exposures. Adult and larger juvenile salmonids appear to be little affected by the high concentrations of suspended sediments that occur during storm and snowmelt runoff episodes (Bjornn and Reiser 1991). However, research shows that chronic exposure can cause physiological stress responses that can increase maintenance energy and reduce feeding and growth (Redding *et al.* 1987, Lloyd 1987, Servizi and Martens 1991).

NOAA Fisheries anticipates that turbidity generated from pile driving will be limited in both space and time and confined to the area close to the operation. NOAA Fisheries does not expect direct lethal take to occur because of turbidity. NOAA Fisheries expects that some individual chinook salmon and steelhead (both adult and juvenile) may be harassed by turbidity plumes resulting from pile driving, but could easily avoid potential plumes. Indirect lethal take could occur if individual juvenile fish are forced (*i.e.*, out of the work area) into an area where they may be preyed upon. Completing the work during the preferred in water work window of November 15 to March 15, implementing a pollution and erosion control plan, treating any construction discharge water, placing restrictions on heavy equipment use and implementing stormwater management requirements will minimize turbidity.

Pilings made of concrete, plastic, steel, treated or untreated wood are used in many construction projects in riparian and aquatic areas. Vibratory or impact hammers are commonly used to drive piles into the substrate. An impact hammer is a heavy weight that is repeatedly dropped onto the top of the pile. A vibratory hammer uses a combination of a stationary, heavy weight and vibration, in the plane perpendicular to the long axis of the pile. The choice of hammer type depends on pile material, substrate type, and other factors. Impact hammers can drive piles into most substrates, including hardpan and glacial till, while vibratory hammers are limited to softer, unconsolidated substrates. However, over-water structures must often meet seismic stability criteria. This requires that the supporting piles be attached to, or driven into, a hard substrate and this often means that at least some impact driving is necessary. Further, the bearing capacity of a pile driven with vibration is unknown unless an impact hammer is used to ‘proof’ the pile by striking it pile several times to ensure it meets the designed bearing capacity.

Pile driving often generates intense sound pressure waves that can injure or kill fish (Reyff 2003, Abbott and Bing-Sawyer 2002, Caltrans 2001, Longmuir and Lively 2001, Stotz and Colby 2001). The type and size of the pile, the firmness of the substrate into which the pile is being driven, the depth of water, and the type and size of the pile-driving hammer all influence the sounds produced during pile driving. Sound pressure is positively correlated with the size of the pile because more energy is required to drive larger piles. Wood and concrete piles produce lower sound pressures than hollow steel piles of a similar size, and may be less harmful to fishes. Firmer substrates require more energy to drive piles and produce more intense sound pressures. Sound attenuates more rapidly with distance from the source in shallow than in deep water (Rogers and Cox 1988). Impact hammers produce intense, sharp spikes of sound that can easily reach levels that harm fishes, and the larger hammers produce more intense sounds. Vibratory hammers, on the other hand, produce sounds of lower intensity, with a rapid repetition rate.

Sound pressure levels (SPLs) greater than 150 decibels (dB) root mean square (RMS) produced when using an impact hammer to drive a pile have been shown to affect fish behavior and cause physical harm when peak SPLs exceed 180 dB (re: 1 microPascal). Surrounding the pile with a bubble curtain can attenuate the peak SPLs by approximately 20 dB and is equivalent to a 90% reduction in sound energy. However, a bubble curtain may not bring the peak and RMS SPLs below the established thresholds, and take may still occur. Without a bubble curtain, SPLs from driving 12 inch diameter steel pilings, measured at 10 m, will be approximately 205 dB_{peak} (Pentec 2003) and 185 dB_{rms}. With a bubble curtain, SPLs are approximately 185 dB_{peak} and 165 dBrms. Using the spherical spreading model to calculate attenuation of the pressure wave (TL = 50*log(R1/R2)), physical injury to sensitive species and life-history stages may occur up to 18 m from the pile driver, and behavioral effects up to 56 m. Studies on pile driving and underwater explosions suggest that, besides attenuating peak pressure, bubble curtains also reduce the impulse energy and, therefore, the potential for injury (Keevin 1998). Because sound pressure attenuates more rapidly in shallow water (Rogers and Cox 1988), it may have fewer deleterious effects there.

Fish respond differently to sounds produced by impact hammers than they do to sounds produced by vibratory hammers. Fish consistently avoid sounds like those of a vibratory hammer (Enger *et al.* 1993; Dolat 1997; Knudsen *et al.* 1997; Sand *et al.* 2000) and appear not to habituate to these sounds, even after repeated exposure (Dolat, 1997; Knudsen *et al.* 1997). On the other hand, fish may respond to the first few strikes of an impact hammer with a ‘startle’ response, but then the startle response wanes and some fish remain within the potentially-harmful area (Dolat 1997). Compared to impact hammers, vibratory hammers make sounds that have a longer duration (minutes vs. milliseconds) and have more energy in the lower frequencies (15-26 Hz vs. 100-800 Hz) (Würsig, *et al.* 2000; Carlson *et al.* 2001; Nedwell and Edwards 2002).

Air bubble systems can reduce the adverse effects of underwater sound pressure levels on fish. Whether confined inside a sleeve made of metal or fabric or unconfined, these systems have been shown to reduce underwater sound pressure (Würsig *et al.* 2000; Longmuir and Lively 2001; Christopherson and Wilson 2002; Reyff and Donovan 2003). Unconfined bubble curtains lower sound pressure by as much as 17 dB (85%) (Würsig *et al.* 2000, Longmuir and Lively 2001), while bubble curtains contained between two layers of fabric reduce sound pressure up to 22 dB (93%) (Christopherson and Wilson, 2002). However, an unconfined bubble curtain can be disrupted and rendered ineffective by currents greater than 1.15 miles per hour (Christopherson and Wilson, 2002). When using an unconfined air bubble system in areas of strong currents, it is essential that the pile be fully contained within the bubble curtain, and that the curtain have adequate air flow, and horizontal and vertical ring spacing around the pile.

Benthic invertebrates in shallow water habitats are key food sources for juvenile salmonids during their outmigration (McCabe *et al.* 1996). New pilings may eliminate substrate available to benthic aquatic organisms and therefore, eliminate a possible food source for juvenile salmonids in the project area. While quantifying the impact this has on salmon populations is difficult, NOAA Fisheries suspects that some impact on chinook and steelhead productivity may occur from suppression of benthic prey species. Most existing commercial dock structures have a high density of existing piles and are not likely significantly used habitat areas for listed salmonids.

Shading from docks, piers, boat houses, and moored boats may also reduce juvenile salmonid prey organism abundance and the complexity of the habitat by reducing aquatic vegetation and phytoplankton abundance (Kahler *et al.* 2000). Glasby (1999) found that epibiotic assemblages on pier pilings at marinas subject to shading were markedly different than in surrounding areas. Fish habitat is enhanced by the diversity of habitat at the land-water interface and adjacent bank (COE 1977). Streamside vegetation provides shade which reduces water temperature. Overhanging branches provide cover from predators. Organisms that fall from overhanging branches may be preyed upon by fish. Immersed vegetation, logs, and root wads provide points of attachment for aquatic prey organisms, shelter from swift currents during high flow events, and retain bed load materials. The proposed planting of approximately 600 linear feet of Columbia River shoreline will improve riparian conditions in the immediate vicinity of the project. The enhancement of these area will offset the effects to listed species from loss of food sources resulting from shading.

<u>Predation</u>

The mainstem portions of rivers serve as an important migration route for numerous species of anadromous fish, whether they key on shallow, nearshore habitats like fall chinook or mid-river like sockeye salmon and steelhead juveniles (Dawley *et al.* 1986). Boat docks and their accompanying in-water structures and upland facilities may affect anadromous fish through: (1) Creation of predatory fish and avian habitat; (2) increasing wave generation and prop wash (sediment suspension) which may result in more disturbance in shallow water habitat; (3) modification of riparian areas; or (4) changes in water quality from run-off.

Juvenile salmonid species such as spring chinook, sockeye, and coho salmon and up-river steelhead usually move down river relatively quickly and in the main channel. This would aid in predator avoidance (Gray and Rondorf 1986). Fall and summer chinook salmon are found in nearshore, littoral habitats and are particularly vulnerable to predation (Gray and Rondorf 1986). Juvenile salmonids (chinook and coho salmon, and cutthroat trout) utilize backwater areas during their out migration (Parente and Smith 1981). In addition, the presence of predators may force smaller prey fish species into less desirable habitats, disrupting foraging behavior, resulting in less growth (Dunsmoor *et al.* 1991).

When a salmon stock suffers from low abundance, predation can contribute significantly to its extinction (Larkin 1979). Further, providing temporary respite from predation may contribute to increasing Pacific salmon (Larkin 1979). A substantial reduction in predators will generally result in an increase in prey (in this case, salmonids) abundance (Campbell 1979). Gray and Rondorf (1986), in evaluating predation in the Columbia River basin, state that "the most effective management program may be to reduce the susceptibility of juvenile salmonids to predation by providing maximum protection during their downstream migration." Campbell (1979), discussing management of large rivers and predator-prey relations, advocates that a "do nothing" approach (as opposed to predator manipulations) coupled with a strong habitat protectionist policy, should receive serious consideration.

Predator species such as northern pikeminnow (*Ptychocheilus oregonensis*), and introduced predators such as largemouth bass, smallmouth bass, black crappie, white crappie and, potentially, walleye (*Stizostedion vitreum*) (Ward *et al.* 1994, Poe *et al.* 1991, Beamesderfer and Rieman 1991, Rieman and Beamesderfer 1991, Petersen *et al.* 1990, Pflug and Pauley 1984, and Collis *et al.* 1995) may utilize habitat created by over-water structures (Ward and Nigro 1992, Pflug and Pauley 1984) such as piers, float houses, floats and docks (Phillips 1990, Kahler *et al.* 2000).

Largemouth bass are considered the principal warmwater predatory fish in the United States (Heidinger 1975, McCammon and von Geldern 1979). Habitat types utilized by largemouth bass include vegetated areas, open water and areas with cover such as docks and submerged trees (Mesing and Wicker 1986, Stuber *et al.* 1982, Miller 1975). Miller (1975) indicates that largemouth bass are primarily lake, pond and quiet water residents. Funk (1975) states that where both smallmouth and largemouth bass co-occur, largemouth bass usually inhabit quiet, weedy, backwater areas. Although they can be found in open water areas, largemouth bass are more commonly found along the shoreline (Heidinger 1975, McCammon and von Geldern 1979). During the summer, bass prefer pilings, rock formations, areas beneath moored boats, and alongside docks. Colle *et al.* (1989) found that, in lakes lacking vegetation, largemouth bass distinctly preferred habitat associated with piers, a situation analogous to the Columbia River. Marinas also provide wintering habitat for largemouth bass out of mainstem current velocities (Raibley *et al.* 1997). Wanjala *et al.* (1986) found that adult largemouth bass in a lake were generally found near submerged structures suitable for ambush feeding.

Bevelhimer (1996), in studies on smallmouth bass, indicates that ambush cover and low light intensities create a predation advantage for predators and can also increase foraging efficiency. Kahler *et al.* (2000) indicate that both smallmouth and largemouth bass utilize docks and piles. Coble (1975), Miller (1975) and Edwards *et al.* (1983) indicate that smallmouth bass prefer streams with moderate currents, gravel or rubble substrate and rocks or logs creating slack water, whereas largemouth bass prefer streams with sluggish current, silt and mud substrate, and aquatic vegetation. Stuber *et al.* (1982) indicate that adult largemouth bass are most abundant in areas of low current velocities and areas with velocities greater than 20 centimeters per second are unsuitable. The slower currents found in many areas of the state's waters make them conducive to largemouth bass.

Black crappie and white crappie are known to prey on juvenile salmonids (Ward *et al.* 1991). Ward *et al.* (1991), in their studies of crappies within the Willamette River, found that the highest density of crappies at their sampling sites occurred at a wharf supported by closely spaced pilings. They further indicated that suitable habitat for crappies includes pilings and riprap areas. Walters *et al.* (1991) also found that crappie were attracted to in-water structures and recommended placement of structures as attractants in lake environs.

Ward (1992) found that stomachs of northern pikeminnow in developed areas of Portland Harbor contained 30% more salmonids than those in undeveloped areas, although undeveloped areas contained more northern pikeminnow. Takata and Ward (2000) in studies of the effects of developments on predators in above Bonneville Dam found that small structures did not appear to have increased predation on juvenile salmonids.

There are four major predatory strategies utilized by piscivorous fish; they run down prey; ambush prey; habituate prey to a non-aggressive illusion; or stalk prey (Hobson 1979). Ambush predation is probably the most common strategy. Predators lie in wait, then dart out at the prey in an explosive rush (Gerking 1994). Predators may use sheltered areas that provide slack water to ambush prey fish in faster currents (Bell 1991).

Light plays an important role in defense from predation. Prey species are better able to see predators under high light intensity, thus providing the prey species with an advantage (Hobson 1979, Helfman 1981). Petersen and Gadomski (1994) found that predator success was higher at lower light intensities. Prey fish lose their ability to school at low light intensities, making them vulnerable to predation (Petersen and Gadomski 1994). Howick and O'Brien (1983) found that in high light intensities prey species (bluegill) can locate largemouth bass before they are seen by the bass. However, in low light intensities, the bass can locate the prey before they are seen. Walters *et al.* (1991) indicate that high light intensities may result in increased use of shade-producing structures. Helfman (1981) found that shade, in conjunction with water clarity, sunlight and vision, is a factor in attraction of temperate lake fishes to overhead structure.

An effect of over-water structures is the creation of a light/dark interface that allows ambush predators to remain in a darkened area (barely visible to prey) and watch for prey to swim by against a bright background (high visibility) (Helfman 1981). Prey species moving around the structure are unable to see predators in the dark area under the structure and are more susceptible to predation. The requirement to incorporate grating into docks and clear or translucent panels on boat houses and coverings will allow for more light penetration and diffuses the light/dark interface. This will minimize the susceptibility of juvenile salmonids to piscivorous predation resulting from these types of projects. Monitoring of the structures with fish counting devices will provide some information as to any usage by fish. The proposal to use videos if significant[1] numbers of fish are present will add further information as to species of fish.

In addition to piscivorous predation, in-water structures (tops of pilings) also provide perching platforms for avian predators such as double-crested cormorants (*Phalacrocorax auritis*), from which they can launch feeding forays or dry plumage. High-energy demands associated with flying and swimming create a need for voracious predation by cormorants on live prey (Ainley 1984). Cormorants are underwater pursuit swimmers (Harrison 1983) that typically feed on mid-water schooling fish (Ainley 1984), but they are known to be highly opportunistic feeders (Derby and Lovvorn 1997, Blackwell *et al.* 1997, Duffy 1995, Schaeffer 1992). Double-crested cormorants are known to fish cooperatively in shallow water areas, herding fish before them (Ainley 1984). Krohn *et al.* (1995) indicate that cormorants can reduce fish populations in forage areas, thus possibly affecting adult returns as a result of smolt consumption. Because their plumage becomes wet when diving, cormorants spend considerable time drying out feathers (Harrison 1983) on pilings and other structures near feeding grounds (Harrison 1984). Placement of piles to support the dock structures will potentially provide for some usage by cormorants. Placement of anti-perching devices on the top of the pilings would preclude their use by any potential avian predators.

<u>Water Quality</u>

Treated wood used for docks releases contaminants into both fresh and saltwater environs. PAHs are commonly released from creosote treated wood. PAHs may cause a variety of deleterious effects (cancer, reproductive anomalies, immune dysfunction, and growth and development impairment) to exposed fish (Johnson 2000, Johnson et al. 1999, Stehr et al. 2000). Wood also is commonly treated with other chemicals such as ammoniacal copper zinc arsenate (ACZA) and chromated copper arsenate (CCA) (Poston 2001). Direct exposure to the contaminants occurs as salmon migrate past installations with treated wood or when the area is used for rearing, and indirect exposure occurs through ingestion of other organisms that have been exposed (Posten 2001). Leaching rates of contaminants from treated wood is highly variable and dependent on many factors (Posten 2001). Consequently, Posten (2001) recommends that use of treated wood for each individual situation needs to be evaluated on its own merits and subject to an evaluation of the pertinent conditions at each site. The use of untreated wood for dock components that may be exposed to water would minimize potential impacts.

[1] To be determined in discussions with NOAA Fisheries and Washington Department of Fish and Wildlife.

The proposed action may also affect listed salmonids as a result of potential for fuel and sewage spills entering the water from either line ruptures or poor handling during vessel fueling or sewage pumping. NOAA Fisheries believes that there is a low likelihood of a rupture occurring. However, a rupture would result in substantial impacts to both food sources (invertebrates) and the fish themselves (Taylor *et al.*, 1995). The water soluble fraction, or components, of fuels may be toxic to fish (Taylor *et al.*, 1995). There are lethal, sublethal and delayed effects from exposure and young organisms are especially vulnerable (Taylor *et al.*, 1995). Short-term effects of oil spills typically involve substantial fish mortality and significant invertebrate population decreases (Taylor *et al.*, 1995). For example, operator error caused a 500 gallon gasoline spill in Bear Creek, Oregon, in 1976, which killed 1,000 trout and steelhead and affected two miles of the creek (Taylor *et al.*, 1995). Impacts to aquatic organisms are usually short-lived in fast flowing, riverine environments (Taylor *et al.*, 1995). Spills into quiescent areas may persist for longer periods. Oil spill clean up is complex and can be hampered by unpreparedness (Bell, 1991). Timeliness is an important factor in the control of spills (Bell, 1991). The training of personnel in emergency response and having appropriate spill containment equipment on site should a line rupture occur would minimize potential impacts.

Poor flushing in marinas in Puget Sound resulted in: (1) Increases in temperature; (2) increased phytoplankton populations with nocturnal dissolved oxygen level declines resulting in organism hypoxia; and (3) pollutant inputs (Cardwell *et al.* 1980a). Water stagnation and fuel, oil, paint, and gasoline spills pose a serious hazard to juveniles in marinas (Heiser and Finn 1970). Elevated residues of heavy metals may be leaching from anti-fouling paint on vessels moored in marinas (Cardwell *et al.* 1980b). Chlorine-based cleaning solutions are also discharged into marinas. An exchange of at least 30% of the water in the marina during a tidal change should minimize temperature increases and dissolved oxygen problems (Cardwell *et al.* 1980a). Ensuring that location of floats in a marina does not diminish water exchange rates should maintain current water quality levels that may be affected by the marina.

Land conversions significantly influence hydrologic processes, increasing the magnitude, frequency, and duration of peak discharges and reducing summer base flows (Booth 1991). These changes occur because of a loss of forest cover and an increase in the impervious surface, along with a replacement of the natural drainage system with an artificial network of storm pipes, drainage ditches and roads (Lucchetti and Fuerstenberg 1993, Booth and Jackson 1997). Roads provide a direct drainage pathway for runoff into the stream system and storm sewer outfalls. Reductions in the natural drainage network and increases in artificial drainage systems shrink the lag time between a rainfall event and the point of peak discharge of stormwater into a stream (Booth and Jackson 1997). This reduction often equates to heightened stormwater peak discharges which cause streambed and streambank scour, mobilize and remove large wood, and extend durations of channel forming flows. This change to the natural hydrology of the stream can have adverse effects on all life stages of salmonids, however, rearing juveniles are particularly vulnerable to being swept downstream during high flows and flows of extended durations.

Imperviousness is a very useful indicator with which to measure effects of land development on aquatic systems. Total impervious area is a physically defined unit which is the sum of roads, parking lots, sidewalks, rooftops, and other impermeable surfaces of the lowland streams landscape. Several studies have provided significant scientific evidence that relates imperviousness to specific changes in hydrology, habitat structure, water quality, and biodiversity of aquatic systems. The body of research — conducted in many geographic areas, concentrating on many different variables, and employing widely different methods — has yielded similar conclusions: Significant stream degradation can occur at relatively low levels of imperviousness (Paul and Meyer 2001). The hydrology of urban streams changes as sites are cleared and natural vegetation is replaced by impervious cover. In addition, since impervious cover prevents rainfall from infiltrating into the soil, less flow is available to recharge ground water. Therefore, during extended periods without rainfall, baseflow levels are often reduced in urban streams. Since the proposed project is located adjacent to the Columbia River, runoff flow is not expected to produce a noticeable effect on base flows of the river.

Water temperature, turbidity, dissolved oxygen (DO), pH, nutrients, and toxic chemicals/metals, all affect water quality and the ability of surface waters to sustain listed salmonids. Each of these factors exhibits natural daily or seasonal fluctuations in magnitude or concentration, and when coupled with the effects of development and stormwater runoff, can exceed the natural range of these factors and alter or impair biological processes.

All salmonids require high levels of DO, which are available in most natural situations. Reduced levels can affect the growth of embryos, alevins, and fry, and the swimming ability of migrating adult and juvenile salmonids. In developed environments, stormwater runoff may reduce DO concentrations by carrying large amounts of organic debris, such as yard waste or leaf litter, and nutrient enrichment (from sewage treatment and agricultural runoff) into streams.

The effect of pH on salmonids is influenced by watershed characteristics and concentrations of dissolved materials in surface waters. However, surface water acidity frequently results from anthropogenic activities related to land use. Low pH adversely affects salmonids by causing respiratory problems for fish, and increasing the mobility and bioavailability of metals to aquatic organisms (Spence *et al.* 1996).

Nutrients, chemicals and metals are potentially widespread in the environment, and surface and groundwaters may be affected by activities that occur with increased development in a basin. In urban streams during storm events, nitrogen and phosphorus are available in some instances at levels that equal or exceed that of sewage effluent (Pitt and Bozeman 1980), with the annual export of nitrogen and orthophosphate from urban streams being 8 and 3 times greater, respectively, than in streams draining forested watersheds (Omernick 1977). This increase in nitrogen and phosphorus comes primarily from wastewater discharges and fertilizer use, and the result can be increased primary productivity elevated to nuisance levels, increasing oxygen demand and decreasing DO levels in the stream. Pesticides are often detected in urban streams at concentrations that frequently exceed guidelines for the protection of aquatic biota (USGS 1999a, Hoffman *et al.* 2000). Sublethal effects such as neurological behavioral effects stemming from standard rates of application of pesticides area a concern. Environmentally relevant concentrations of diazinon (USGS 1999b) have been shown to disrupt homing and anti-predator behaviors in chinook salmon (Scholtz *et al.* 2000). Other organic contaminants in urban streams include polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and petroleum-based aliphatic hydrocarbons, all frequently found at levels exceeding human health criteria or at levels stressful to sensitive aquatic organisms (Paul and Meyer 2001). Natural metal concentrations in surface water vary regionally, however, a common feature of urban streams is elevated water column and sediment metal concentrations, including lead, zinc, chromium, copper, manganese, nickel and cadmium, which increase with increased percentages of urban land use (Wilber and Hunter 1979). In addition to industrial discharges, other sources of metals are brake linings, tires, and metal alloys for engine parts. Although some metals are necessary trace nutrients, many metals are toxic to fish at very low concentrations (Spence *et al.* 1996).

The proposed project may include development of upland areas in the future that will have substantial impervious surfaces. The BA did not address how these upland areas would be developed. Development may ultimately hinge on the extent of marina development. Upland development potentially could result in impacts described above. Treatment (1.8 inches of the 2-year storm, which equates to 72% of the 2-year, 24-hour storm) of the stormwater runoff from parking lots, roofs and sidewalks would minimize potential effects on listed species.

<u>Boating Activities</u>

Residential docks and especially marinas are likely to have high levels of boating activity in their immediate vicinity, particularly adjacent to floats. Specifically, docks may serve as a mooring area for boats or a staging platform for recreational boating activities. There are several impacts boating activity may have on listed salmonids and aquatic habitat. Directly, engine noise, prop movement, and the physical presence of a boat hull may disrupt or displace nearby fishes (Mueller 1980, Warrington 1999a).

Boat traffic may also cause: (1) Increased turbidity in shallow waters; (2) uprooting of aquatic macrophytes in shallow waters; or (3) aquatic pollution (through exhaust, fuel spills, or release of petroleum lubricants) (Warrington 1999b). Nordstrom (1989) indicates that boat wakes may also play a significant role in creating erosion in narrow creeks entering a estuary (areas that are extensively used by rearing juvenile salmonids). These boating impacts indirectly affect listed fish in a number of ways. Turbidity may injure or stress affected fishes (see above). The loss of aquatic macrophytes may expose salmonids to predation, decrease littoral productivity, or alter local species assemblages and trophic interactions. Despite a general lack of data specifically for salmonids, pollution from boats may cause short-term injury, physiological stress, decreased reproductive success, cancer, or death for fishes in general. Further, pollution may also impact fishes by impacts to potential prey species or aquatic vegetation. These impacts may be minimized by restricting the areas where location of the floats within the marina may occur to areas devoid of aquatic vegetation. They may also be further minimized by educating the boating public in pollution and the subsequent impacts to resources and ways to minimize those impacts.

2.1.6 Critical Habitat

NOAA Fisheries designates critical habitat based on physical and biological features that are essential to the listed species. Essential features for designated critical habitat include substrate, water quality, water quantity, water temperature, food, riparian vegetation, access, water velocity, space and safe passage. The proposed action is within critical habitat for SR sockeye salmon and SR fall run and spring/summer run chinook salmon. Effects to critical habitat from these categories are included in the effects description expressed above.

2.1.7 Cumulative Effects

Cumulative effects are defined in 50 CFR 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." For the purposes of this analysis, the action area encompasses the immediate area around the project site and downriver to Bonneville Dam. Future Federal actions, including the ongoing operation of hydropower systems, hatcheries, fisheries, and land management activities are being (or have been) reviewed through separate section 7 consultation processes.

NOAA Fisheries assumes that future private and state actions will continue within the action area, but at increasingly higher levels as population density climbs. Non-federal actions that may take listed salmonids require authorization under section 10 of the ESA. The effects of these actions will be evaluated during the section 10 review process. Therefore, these actions are not considered cumulative to the proposed action.

2.1.8 Conclusion

After reviewing the best scientific and commercial information available regarding the current status of the listed salmonids considered in this Opinion, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NOAA Fisheries' opinion that the proposed Gorge Harbor Marina project is not likely to jeopardize the continued existence of SR sockeye salmon, SR spring/summer chinook salmon, SR fall chinook salmon, LCR steelhead, UCR steelhead, SR steelhead, MCR steelhead, LCR chinook salmon, UCR spring-run chinook salmon and/or result in the destruction or adverse modification of designated critical habitat.

This conclusion is based on the following: (1) In-water structures are designed in such a way as to minimize the potential for predator usage; (2) construction impacts should be minimized by the proposed timing of construction work and methodologies; (3) water quality impacts should be minimal or not increased beyond that already experienced in the area; and (4) the proposed plantings should improve the riparian areas at the site.

2.1.9 Reinitiation of Consultation

Consultation must be reinitiated if: (1) The amount or extent of taking specified in the incidental take statement is exceeded, or is expected to be exceeded; (2) new information reveals effects of the action may affect listed species in a way not previously considered; (3) the action is modified in a way that causes an effect on listed species that was not previously considered; or (4) a new species is listed or critical habitat is designated that may be affected by the action (50 CFR 402.16).

2.2 Incidental Take Statement

The ESA at section 9 [16 USC 1538] prohibits take of endangered species. The prohibition of take is extended to threatened anadromous salmonids by section 4(d) rule [50 CFR 223.203]. Take is defined by the statute as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." [16 USC 1532(19)] Harm is defined by regulation as "an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavior patterns, including, breeding, spawning, rearing, migrating, feeding or sheltering." [50 CFR 222.102] Harass is defined as "an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering." [50 CFR 17.3] Incidental take is defined as "takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant." [50 CFR 402.02] The ESA at section 7(o)(2) removes the prohibition from any incidental taking that is in compliance with the terms and conditions specified in a section 7(b)(4) incidental take statement [16 USC 1536].

The measures described below are non-discretionary; they must be implemented by the action agency so that they become binding conditions of any grant or permit issued to the applicant, as appropriate, in order for the exemption in section 7(o)(2) to apply. The COE has a continuing duty to regulate the activity covered in this incidental take statement. If the COE: (1) Fails to require the applicant to adhere to the terms and conditions of the incidental take statement through enforceable terms that are added to the permit or grant document; and/or (2) fails to retain the oversight to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

An incidental take statement specifies the impact of any incidental taking of endangered or threatened species. It also provides reasonable and prudent measures that are necessary to minimize impacts and sets forth terms and conditions with which the action agency must comply in order to implement the reasonable and prudent measures.

2.2.1 Amount or Extent of the Take

NOAA Fisheries anticipates that the action covered by this Opinion is reasonably certain to result in incidental take of listed and proposed species because of: (1) Continued predation by predaceous fish utilizing in-water structures; (2) construction impacts; (3) sound generated by pile driving; (4) short-term increases in turbidity; (5) boating activities; and (6) storm water from upland development and potential sewage or fuel spills. The subject action, however, as described in the Opinion and modified by the reasonable and prudent measures and terms and conditions, is expected to result in a substantial decline in the extent of take. Effects of the action such as these are largely unquantifiable, but are not expected to be measurable as long-term effects on the species' habitat or population levels. The best scientific and commercial data available are not sufficient to enable NOAA Fisheries to estimate a specific amount of incidental take to the listed species themselves. In instances such as these, NOAA Fisheries designates the expected level of take as "unquantifiable". Based on the information in the BA, NOAA Fisheries anticipates that an unquantifiable amount of incidental take could occur as a result of the action covered by this Opinion.

The extent of take is limited to activities described within this Opinion within the action area. The action area is the excavated backwater area and the Columbia River within 300 feet upstream and downstream of the project site.

2.2.2 Reasonable and Prudent Measures

NOAA Fisheries believes that the following reasonable and prudent measure(s) are necessary and appropriate to avoid take of the listed and proposed species.

The COE shall:

1. Minimize the amount and extent of incidental take from general construction activities by applying permit conditions that avoid or minimize adverse effects to riparian and aquatic systems.

2. Minimize incidental take from over-water and in-water structures by excluding unauthorized permit actions and applying permit conditions or project specifications that avoid or minimize adverse effects to riparian and aquatic systems.

3. Ensure completion of a comprehensive monitoring and reporting program to confirm that the terms and conditions are meeting the objective of minimizing take.

2.2.3 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the COE must comply with the following terms and conditions, which implement the reasonable and prudent measures described above. These terms and conditions are non-discretionary.

1. To implement reasonable and prudent measure #1 (general conditions for construction, operation and maintenance), the COE shall ensure that:

   a. Timing of in-water work. Work below the bankfull elevation[2] will be completed during the preferred in-water work period of November 15 to March 15, unless otherwise approved, in writing, by NOAA Fisheries.
   b. Cessation of work. Cease project operations under high flow conditions that may result in inundation of the project area, except for efforts to avoid or minimize resource damage.
   c. Pollution and Erosion Control Plan. Prepare and carry out a pollution and erosion control plan to prevent pollution caused by surveying or construction operations. The plan must be available for inspection on request by COE or NOAA Fisheries.
      i. Plan Contents. The pollution and erosion control plan will contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.
         (1) The name and address of the party(s) responsible for accomplishment of the pollution and erosion control plan.
         (2) Practices to prevent erosion and sedimentation associated with access roads, stream crossings, drilling sites, construction sites, borrow pit operations, haul roads, equipment and material storage sites, fueling operations, staging areas, and roads being decommissioned.
         (3) Practices to confine, remove and dispose of excess concrete, cement, grout, and other mortars or bonding agents, including measures for washout facilities.
         (4) A description of any regulated or hazardous products or materials that will be used for the project, including procedures for inventory, storage, handling, and monitoring.
         (5) A spill containment and control plan with notification procedures, specific cleanup and disposal instructions for different products, quick response containment and cleanup measures that will be available on the site, proposed methods for disposal of spilled materials, and employee training for spill containment.
         (6) Practices to prevent construction debris from dropping into any stream or water body, and to remove any material that does drop with a minimum disturbance to the streambed and water quality.
      ii. Inspection of erosion controls. During construction, monitor instream turbidity and inspect all erosion controls daily during the rainy season and

[2] 'Bankfull elevation' means the bank height inundated by a 1.5 to 2-year average recurrence interval and may be estimated by morphological features such average bank height, scour lines and vegetation limits.

weekly during the dry season, or more often as necessary, to ensure the erosion controls are working adequately.[3]

(1) If monitoring or inspection shows that the erosion controls are ineffective, mobilize work crews immediately to make repairs, install replacements, or install additional controls as necessary.

(2) Remove sediment from erosion controls once it has reached 1/3 of the exposed height of the control.

d. Construction discharge water. Treat all discharge water created by construction (*e.g.*, concrete washout, pumping for work area isolation, vehicle wash water, drilling fluids) as follows:

i. Water quality. Design, build and maintain facilities to collect and treat all construction discharge water, including any contaminated water produced by drilling, using the best available technology applicable to site conditions. Provide treatment to remove debris, nutrients, sediment, petroleum hydrocarbons, metals and other pollutants likely to be present.

ii. Discharge velocity. If construction discharge water is released using an outfall or diffuser port, velocities may not exceed 4 feet per second, and the maximum size of any aperture may not exceed one inch.

iii. Pollutants. Do not allow pollutants including green concrete, contaminated water, silt, welding slag, sandblasting abrasive, or grout cured less than 24 hours to contact any wetland or the 2-year floodplain.

e. Piling installation. Install temporary and permanent pilings as follows:

i. Minimize the number and diameter of pilings, as appropriate, without reducing structural integrity.

ii. Repairs, upgrades, and replacement of existing pilings consistent with these terms and conditions are allowed.

iii. In addition to repairs, upgrades, and replacements of existing pilings, up to five single pilings or one dolphin consisting of three to five pilings may be added to an existing facility per in-water construction period.

iv. Drive each piling as follows to minimize the use of force and resulting sound pressure.

(1) Hollow steel pilings greater than 24 inches in diameter, and H-piles larger than designation HP24, are not authorized under this Opinion.

(2) When impact drivers will be used to install a pile, use the smallest driver and the minimum force necessary to complete the job. Use a drop hammer or a hydraulic impact hammer, whenever feasible and set the drop height to the minimum necessary to drive the piling.

---

[3] 'Working adequately' means that project activities do not increase ambient stream turbidity by more than 10% above background 100 feet below the discharge, when measured relative to a control point immediately upstream of the turbidity causing activity.

(3) When using an impact hammer to drive or proof steel piles, one of the following sound attenuation devices will be used to reduce sound pressure levels by 20 decibels.

(a) Place a block of wood or other sound dampening material between the hammer and the piling being driven.

(b) If currents are 1.7 miles per hour or less, surround the piling being driven by an unconfined bubble curtain that will distribute small air bubbles around 100% of the piling perimeter for the full depth of the water column.[4]

(c) If currents greater than 1.7 miles per hour, surround the piling being driven by a confined bubble curtain (*e.g.*, a bubble ring surrounded by a fabric or metal sleeve) that will distribute air bubbles around 100% of the piling perimeter for the full depth of the water column.

(d) Other sound attenuation devices as approved, in writing, by NOAA Fisheries.

f. Piling removal. If a temporary or permanent piling will be removed, the following conditions apply:

i. Dislodge the piling with a vibratory hammer.

ii. Once loose, place the piling onto the construction barge or other appropriate dry storage site.

iii. If a treated wood piling breaks during removal, either remove the stump by breaking or cutting 3 feet below the sediment surface or push the stump in to that depth, then cover it with a cap of clean substrate appropriate for the site.

iv. Fill the holes left by each piling with clean, native sediments, whenever feasible.

g. Treated wood.

i. If the project requires removal of treated wood, use the following precautions:

(1) Treated wood debris. Take care to ensure that no treated wood debris falls into the water. If treated wood debris does fall into the water, remove it immediately.

(2) Disposal of treated wood debris. Dispose of all treated wood debris removed during a project, including treated wood pilings, at an upland facility approved for hazardous materials of this

---

[4] For guidance on how to deploy an effective, economical bubble curtain, see, Longmuir, C. and T. Lively, *Bubble Curtain Systems for Use During Marine Pile Driving*, Fraser River Pile and Dredge LTD, 1830 River Drive, New Westminster, British Columbia, V3M 2A8, Canada. Recommended components include a high volume air compressor that can supply more than 100 pounds per square inch at 150 cubic feet per minute to a distribution manifold with 1/16 inch diameter air release holes spaced every 3/4 inch along its length. An additional distribution manifold is needed for each 35 feet of water depth.

classification. Do not leave a treated wood piling in the water or stacked on the stream bank.

h. Preconstruction activity. Complete the following actions before significant[5] alteration of the project area.

  i. Marking. Flag the boundaries of clearing limits associated with site access and construction to prevent ground disturbance of critical riparian vegetation, wetlands and other sensitive sites beyond the flagged boundary.

  ii. Emergency erosion controls. Ensure that the following materials for emergency erosion control are onsite.

    (1) A supply of sediment control materials (*e.g.*, silt fence, straw bales[6]).

    (2) An oil-absorbing, floating boom whenever surface water is present.

  iii. Temporary erosion controls. All temporary erosion controls will be in-place and appropriately installed downslope of project activity within the riparian area until site restoration is complete.

i. Heavy Equipment. Restrict use of heavy equipment as follows:

  i. Choice of equipment. When heavy equipment will be used, the equipment selected will have the least adverse effects on the environment (*e.g.*, minimally sized, low ground pressure equipment).

  ii. Vehicle and material staging. Store construction materials, and fuel, operate, maintain and store vehicles as follows:

    (1) To reduce the staging area and potential for contamination, ensure that only enough supplies and equipment to complete a specific job will be stored on-site.

    (2) Complete vehicle staging, cleaning, maintenance, refueling, and fuel storage in a vehicle staging area placed 150 feet or more from any stream, water body or wetland, unless otherwise approved in writing by NOAA Fisheries.

    (3) Inspect all vehicles operated within 150 feet of any stream, water body or wetland daily for fluid leaks before leaving the vehicle staging area. Repair any leaks detected in the vehicle staging area before the vehicle resumes operation. Document inspections in a record that is available for review on request by COE or NOAA Fisheries.

    (4) Before operations begin and as often as necessary during operation, steam clean all equipment that will be used below bankfull elevation until all visible external oil, grease, mud, and other visible contaminates are removed.

---

[5] 'Significant' means an effect can be meaningfully measured, detected or evaluated.

[6] When available, certified weed-free straw or hay bales will be used to prevent introduction of noxious weeds.

(5) Diaper all stationary power equipment (*e.g.*, generators, cranes, stationary drilling equipment) operated within 150 feet of any stream, waterbody or wetland to prevent leaks, unless suitable containment is provided to prevent potential spills from entering any stream or waterbody.

j. Site preparation. Conserve native materials for site restoration.

i. If possible, leave native materials where they are found.

ii. If materials are moved, damaged or destroyed, replace them with a functional equivalent during site restoration.

iii. Stockpile any large wood,[7] native vegetation, weed-free topsoil, and native channel material displaced by construction for use during site restoration.

k. Earthwork. Complete earthwork (including drilling, excavation, dredging, filling and compacting) as quickly as possible.

i. Site stabilization. Stabilize all disturbed areas, including obliteration of temporary roads, following any break-in work unless construction will resume within four days.

ii. Source of materials. Obtain boulders, rock, woody materials and other natural construction materials used for the project outside the riparian area.

l. Stormwater management. As upland areas are developed, prepare and carry out a stormwater management plan that will produce a new impervious surface or a land cover conversion that slows the entry of water into the soil. The plan must be available for inspection on request by COE or NOAA Fisheries.

i. Plan contents. The goal is to avoid and minimize adverse effects due to the quantity and quality of stormwater runoff for the life of the project by maintaining or restoring natural runoff conditions. The plan will meet the following criteria and contain the pertinent elements listed below, and meet requirements of all applicable laws and regulations.

(1) A system of management practices and, if necessary, structural facilities, designed to complete the following functions.

(a) Minimize, disperse and infiltrate stormwater runoff onsite using sheet flow across permeable vegetated areas to the maximum extent possible without causing flooding, erosion impacts, or long-term adverse effects to groundwater.

(b) Pretreat stormwater from pollution generating surfaces before infiltration or discharge into a freshwater system, as necessary to minimize any nonpoint source pollutant (*e.g.*,

---

[7] For purposes of this Opinion only, 'large wood' means a tree, log, or rootwad big enough to dissipate stream energy associated with high flows, capture bedload, stabilize streambanks, influence channel characteristics, and otherwise support aquatic habitat function, given the slope and bankfull channel width of the stream in which the wood occurs. See, Oregon Department of Forestry and Oregon Department of Fish and Wildlife, *A Guide to Placing Large Wood in Streams*, May 1995 (www.odf.state.or.us/FP/RefLibrary/LargeWoodPlacemntGuide5-95.doc).

debris, sediment, nutrients, petroleum hydrocarbons, metals) likely to be present in the volume of runoff predicted from a 6-month, 24-hour storm.[8]

(2) For projects that require engineered facilities to meet stormwater requirements, use a continuous rainfall/runoff model, if available for the project area, to calculate stormwater facility water quality and flow control rates.

(3) Use permeable pavements for load-bearing surfaces, including multiple-use trails, to the maximum extent feasible based on soil, slope, and traffic conditions.

(4) Install structural facilities outside wetlands or the riparian buffer area[9] whenever feasible, otherwise, provide compensatory mitigation to offset any long-term adverse effects.

(5) Document completion of the following activities according to a regular schedule for the operation, inspection and maintenance of all structural facilities and conveyance systems, in a log available for inspection on request by the COE and NOAA Fisheries.

(a) Inspect and clean each facility as necessary to ensure that the design capacity is not exceeded, heavy sediment discharges are prevented, and whether improvements in operation and maintenance are needed.

(b) Promptly repair any deterioration threatening the effectiveness of any facility.

(c) Post and maintain a warning sign on or next to any storm drain inlet that says, as appropriate for the receiving water, 'Dump No Waste - Drains to Ground Water, Streams, or Lakes'.

(d) Only dispose of sediment and liquid from any catch basin in an approved facility.

ii. Runoffs/discharge into a freshwater system. When stormwater runoff will be discharged directly into fresh surface water or a wetland, or indirectly through a conveyance system, the following requirements apply.

---

[8] A 6-month, 24-hour storm may be assumed to be 72% of the 2-year, 24-hour amount. See, Washington State Department of Ecology (2001), Appendix I-B-1.

[9] For purposes of this Opinion only, 'riparian buffer area' means land: (1) Within 150 feet of any natural water occupied by listed salmonids during any part of the year or designated as critical habitat; (2) within 100 feet of any natural water within 1/4 mile upstream of areas occupied by listed salmonids or designated as critical habitat and that is physically connected by an above-ground channel system such that water, sediment, or woody material delivered to such waters will eventually be delivered to water occupied by listed salmon or designated as critical habitat; and (3) within 50 feet of any natural water upstream of areas occupied by listed salmonids or designated as critical habitat and that is physically connected by an above-ground channel system such that water, sediment, or woody material delivered to such waters will eventually be delivered to water occupied by listed salmon or designated as critical habitat. 'Natural water' means all perennial or seasonal waters except water conveyance systems that are artificially constructed and actively maintained for irrigation.

(1) Maintain natural drainage patterns and, whenever possible, ensure that discharges from the project site occur at the natural location.
(2) Use a conveyance system comprised entirely of manufactured elements (*e.g.*, pipes, ditches, outfall protection) that extends to the ordinary high water line of the receiving water.
(3) Stabilize any erodible elements of this system as necessary to prevent erosion.
(4) Do not divert surface water from, or increase discharge to, an existing wetland if that will cause a significant adverse effect to wetland hydrology, soils or vegetation.
(5) The velocity of discharge water released from an outfall or diffuser port may not exceed 4 feet per second, and the maximum size of any aperture may not exceed one inch.

m. Site restoration. Prepare and carry out a site restoration plan as necessary to ensure that all streambanks, soils and vegetation disturbed by the project are cleaned up and restored as follows. Make the written plan available for inspection on request by the COE or NOAA Fisheries.

i. General considerations.

(1) Restoration goal. The goal of site restoration is renewal of habitat access, water quality, production of habitat elements (*e.g.*, large woody debris), channel conditions, flows, watershed conditions and other ecosystem processes that form and maintain productive fish habitats.
(2) Revegetation. Replant each area requiring revegetation before the first April 15 following construction. Use a diverse assemblage of species native to the project area or region, including grasses, forbs, shrubs and trees. Noxious or invasive species may not be used.
(3) Pesticides. Take of ESA-listed species caused by any aspect of pesticide use is not included in the exemption to the ESA take prohibitions provided by this incidental take statement. Pesticide use must be evaluated in an individual consultation, although mechanical or other methods may be used to control weeds and unwanted vegetation.
(4) Fertilizer. Do not apply surface fertilizer within 50 feet of any stream channel.

ii. Plan contents. Include each of the following elements:

(1) Responsible party. The name and address of the party(s) responsible for meeting each component of the site restoration requirements, including providing and managing any financial assurances and monitoring necessary to ensure restoration success.
(2) Baseline information. This information may be obtained from existing sources (*e.g.*, land use plans, watershed analyses, subbasin plans), where available.

(a) A functional assessment of adverse effects, *i.e.*, the location, extent and function of the riparian and aquatic resources that will be adversely affected by construction and operation of the project.

(b) The location and extent of resources surrounding the restoration site, including historic and existing conditions.

(3) Goals and objectives. Restoration goals and objectives that describe the extent of site restoration necessary to offset adverse effects of the project, by aquatic resource type.

(4) Performance standards. Use these standards to help design the plan and to assess whether the restoration goal is met. While no single criterion is sufficient to measure success, the intent is that these features should be present within reasonable limits of natural and management variation.

(a) Bare soil spaces are small and well dispersed.

(b) Soil movement, such as active rills or gullies and soil deposition around plants or in small basins, is absent or slight and local.

(c) If areas with past erosion are present, they are completely stabilized and healed.

(d) Plant litter is well distributed and effective in protecting the soil with few or no litter dams present.

(e) Native woody and herbaceous vegetation, and germination microsites, are present and well distributed across the site.

(f) Vegetation structure is resulting in rooting throughout the available soil profile.

(g) Plants have normal, vigorous growth form, and a high probability of remaining vigorous, healthy and dominant over undesired competing vegetation.

(h) High impact conditions confined to small areas necessary access or other special management situations.

(i) Streambanks have less than 5% exposed soils with margins anchored by deeply rooted vegetation or coarse-grained alluvial debris.

(j) Few upland plants are in valley bottom locations, and a continuous corridor of shrubs and trees provide shade for the entire streambank.

(5) Work plan. Develop a work plan with sufficient detail to include a description of the following elements, as applicable.

(a) Boundaries for the restoration area.

(b) Restoration methods, timing, and sequence.

(c) Water supply source, if necessary.

(d) Woody native vegetation appropriate to the restoration site.[10] This must be a diverse assemblage of species that are native to the project area or region, including grasses, forbs, shrubs and trees. This may include allowances for natural regeneration from an existing seed bank or planting.

(e) A plan to control exotic invasive vegetation.

(f) Elevation(s) and slope(s) of the restoration area to ensure they conform with required elevation and hydrologic requirements of target plant species.

(g) Geomorphology and habitat features of stream or other open water.

(h) Site management and maintenance requirements.

(6) Five-year monitoring and maintenance plan.

(a) A schedule to visit the restoration site annually for 5 years or longer as necessary to confirm that the performance standards are achieved. Despite the initial 5-year planning period, site visits and monitoring will continue from year-to-year until the COE certifies that site restoration performance standards have been met.

(b) During each visit, inspect for and correct any factors that may prevent attainment of performance standards (*e.g.*, low plant survival, invasive species, wildlife damage, drought).

(c) Keep a written record to document the date of each visit, site conditions and any corrective actions taken.

2. To implement reasonable and prudent measure #2 (over-water and in-water structures), the COE shall ensure that:

a. General. The following general conditions apply to over-water and in-water structures.

iii. Docks, piers or walkways.

(1) For all docks wider than 6 feet one of the following shall apply: 8-foot wide floats shall be no longer the 4 feet and shall incorporate 18-24 inches of grating between them; 8-foot wide floats longer than 4 feet shall incorporate two rows of 1-foot diameter tubes on 2 foot center located on both outside edges of the float; translucent docks shall not be limited in length; or another design for structures wider than 6 feet approved, in writing, by NOAA Fisheries.

(2) Floatation shall be located under the solid decked areas only.

[10] Use references sites to select vegetation for the mitigation site whenever feasible. Historic reconstruction, vegetation models, or other ecologically-based methods may also be used as appropriate.

(3) The gangways shall be covered with grating that passes a minimum of 60% sunlight.

(4) The grated areas shall not be used for storage purposes, either on the floats, piers, or gangways.

(5) Floating structures shall be located at least 50 feet away from the shoreline and clear at least 10 feet of water under the floats during low pool season, except for the access dock extension adjacent to the existing boat ramp.

(6) The piers, gangways, floats and associated moorings shall be located to avoid shading of aquatic vegetation.

iv. Floating Boathouses. The following provisions shall apply to all boat houses, including combination boathouses.

(1) Each boathouse shall be no more than 30 feet wide and 50 feet long.

(2) Each boathouse shall support a boat well that is at least 14 feet wide.

(3) Each boathouse shall be constructed for maximum light penetration, and shall include all of the following features:

(a) A minimum of two 12+ inch diameter solar tubes shall be installed in the forward covered part of the structure (in the 12-foott by 30-foot area ahead of the boat well).

(b) A clear or translucent garage door shall be installed at the water entry end of boathouse, unless the entry is left open.

(c) Clear glass, clear plastic or translucent side windows shall be installed on each side of the boathouse. These shall be at least 6 feet tall, starting near the lower ceiling of the structure, and shall be at least 35 feet long. The clear area may be interrupted by the minimum necessary structural supports and "window pane" separators.

(d) The interior of the boat well shall be painted white in order to allow maximum brightness within the boat well area.

(4) All combination boathouses shall be separated by at least 14 feet wide boat slips, to allow light penetration.

v. Piscivorus bird deterrence. Fit all pilings, mooring buoys, and navigational aids (*e.g.*, channel markers) with devices to prevent perching by piscivorus birds.

vi. Removal of large wood debris obstructions. When floating or submerged large wood debris must be moved to allow the reasonable use of an over-water or in-water facility, ensure that the wood is returned to the water downstream where it will continue to provide aquatic habitat function.

vii. Flotation.

(1) Permanently encapsulate all synthetic flotation material to prevent breakup into small pieces and dispersal in water.

(2) Install mooring buoys as necessary to ensure that moored boats do not ground out or prop wash the bottom.

viii. Educational Signs. Because the best way to minimize adverse effects caused by boating is to educate the public about pollution and its prevention, post the following information on a permanent sign that will be maintained at each permitted facility used by the public (such as marinas, public boat ramps, *etc.*).

(1) A description of the ESA-listed salmonids which are or may be present in the project area.

(2) Notice that the adults and juveniles of these species, and their habitats, are be protected so that they can successfully migrate, spawn, rear, and complete other behaviors necessary for their recovery.

(3) Lack of necessary habitat conditions may result in a variety of adverse effects including direct mortality, migration delay, reduced spawning, loss of food sources, reduced growth, reduced populations, and decreased productivity.

(4) Therefore, all users of the facility are encouraged or required to:

(a) Follow procedures and rules governing use of sewage pump-out facilities.

(b) Minimize the fuel and oil released into surface waters during fueling, and from bilges and gas tanks.

(c) Avoid cleaning boat hulls in the water to prevent the release of cleaner, paint and solvent.

(d) Practice sound fish cleaning and waste management, including proper disposal of fish waste.

(e) Dispose of all solid and liquid waste produced while boating in a proper facility away from surface waters.

ix. Spill containment. Minimize potential adverse effects on listed species caused by accidental spills of fuel or sewage from vessels and stations.

(1) Sufficient supplies are maintained on site to prevent a fuel leak from spreading to the Columbia River and adequate equipment necessary to deploy them.

(2) Signage detailing emergency actions in the event of a gasoline of sewage spill shall be installed. Training in emergency procedures shall be provided to all employees of the facility within one week of their starting date.

(3) Sewage pumping facilities shall be installed with automatic shut off valves.

(4) A spill response plan shall be developed and implemented prior to installation of sewage pumping facilities.

b. The COE shall inspect the site at the completion of each phase of construction to ascertain if the required construction standards have been met.

c. The COE shall require that any covered moorage (other than the combination boat houses) shall be open on the sides and the covering shall be of a translucent material that shall not block sunlight or other type approved in writing by NOAA Fisheries.

d. The COE shall require that the applicant monitor predaceous fish usage of the facility for after the first phase of construction to ascertain the extent of usage and feeding habits. The applicant shall supply to the COE and NOAA Fisheries a report detailing the results of the sampling prior to building Phase 2. If predaceous fish are using the facility in numbers deemed by NOAA Fisheries to pose risk to juvenile salmonids, the applicant shall work with NOAA Fisheries and the COE to devise further means of predatory fish dissuasion.

   i. One fish counting device shall be installed under the darkest area of every fifth combination boathouse in order to monitor how fish presence may be affected by the structure. Two other fish counting devices shall be located in other areas of the marina not subject to significant shading. This portion of the project shall be conducted and monitored by a qualified fisheries biologist. If significant fish numbers (to be determined in discussions with NOAA Fisheries and Washington Department of Fish and Wildlife) are detected, the applicant shall use video devices or other means to determine the type of fish present.

3. To implement reasonable and prudent measure #4 (monitoring), the COE shall:

a. Implementation monitoring. Ensure that each applicant submits a monitoring report to the COE within 120 days of project completion describing the applicant's success meeting his or her permit conditions. Each project level monitoring report will include the following information.

   i. Project identification
      (1) Applicant name, permit number, and project name.
      (2) Type of activity.
      (3) Project location, including any compensatory mitigation site(s), by 5th field HUC and by latitude and longitude as determined from the appropriate USGS 7-minute quadrangle map.
      (4) COE contact person.
      (5) Starting and ending dates for work completed.

   ii. Photo documentation. Photos of habitat conditions at the project and any compensation site(s), before, during, and after project completion.[11]
      (1) Include general views and close-ups showing details of the project and project area, including pre and post construction.

[11] Relevant habitat conditions may include characteristics of channels, eroding and stable streambanks in the project area, riparian vegetation, water quality, flows at base, bankfull and over-bankfull stages, and other visually discernable environmental conditions at the project area, and upstream and downstream of the project.

(2) Label each photo with date, time, project name, photographer's name, and a comment about the subject.

iii. Other data. Additional project-specific data, as appropriate for individual projects.

(1) Pollution control. A summary of pollution and erosion control inspections, including any erosion control failure, contaminant release, and correction effort.

(2) Pilings.

(a) Number and type of pilings removed, including the number of pilings (if any) that broke during removal.

(b) Number, type, and diameter of any pilings installed (*e.g.*, untreated wood, treated wood, hollow steel).

(c) Description of how pilings were installed and any sound attenuation measures used..

(3) Site preparation.

(a) Total cleared area – riparian and upland.

(b) Total new impervious area.

(4) Minor discharge and excavation/dredging.

(a) Volume of dredged material.

(b) Water depth before dredging and within one week of completion.

(c) Verification of upland dredge disposal.

(5) Site restoration. Photo or other documentation that site restoration performance standards were met.

(6) Long-term habitat loss. The same elements apply as for monitoring site restoration.

iv. Site restoration or compensatory mitigation monitoring. In addition to the 120-day implementation report, the applicant will submit an annual report by December 31 that includes the written record documenting the date of each visit to a restoration site or mitigation site, and the site conditions and any corrective action taken during that visit. Reporting will continue from year to year until the COE certifies that site restoration or compensatory mitigation performance standards have been met.

(b) NOTICE. If a sick, injured or dead specimen of a threatened or endangered species is found, the finder must notify the Vancouver Field Office of NOAA Fisheries Law Enforcement at 360.418.4246. The finder must take care in handling of sick or injured specimens to ensure effective treatment, and in handling dead specimens to preserve biological material in the best possible condition for later analysis of cause of death. The finder also has the responsibility to carry out instructions provided by Law Enforcement to ensure that evidence intrinsic to the specimen is not disturbed unnecessarily.

3. MAGNUSON-STEVENS ACT

3.1 Background

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), established procedures designed to identify, conserve, and enhance essential fish habitat (EFH) for those species regulated under a Federal fisheries management plan. Pursuant to the MSA:

- Federal agencies must consult with NOAA Fisheries on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH (§305(b)(2)).
- NOAA Fisheries must provide conservation recommendations for any Federal or state action that would adversely affect EFH (§305(b)(4)(A)).
- Federal agencies must provide a detailed response in writing to NOAA Fisheries within 30 days after receiving EFH conservation recommendations. The response must include a description of measures proposed by the agency for avoiding, mitigating, or offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with NOAA Fisheries EFH conservation recommendations, the Federal agency must explain its reasons for not following the recommendations (§305(b)(4)(B)).

EFH means those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (MSA §3). For the purpose of interpreting this definition of EFH: Waters include aquatic areas and their associated physical, chemical, and biological properties that are used by fish and may include aquatic areas historically used by fish where appropriate; substrate includes sediment, hard bottom, structures underlying the waters, and associated biological communities; necessary means the habitat required to support a sustainable fishery and the managed species' contribution to a healthy ecosystem; "spawning, breeding, feeding, or growth to maturity" covers a species' full life cycle (50 CFR 600.10). Adverse effect means any impact which reduces quality and/or quantity of EFH, and may include direct (*e.g.*, contamination or physical disruption), indirect (*e.g.*, loss of prey or reduction in species fecundity), site-specific or habitat-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 CFR 600.810).

EFH consultation with NOAA Fisheries is required regarding any Federal agency action that may adversely affect EFH, including actions that occur outside EFH, such as certain upstream and upslope activities.

The objectives of this EFH consultation are to determine whether the proposed action would adversely affect designated EFH and to recommend conservation measures to avoid, minimize, or otherwise offset potential adverse effects to EFH.

3.2 Identification of EFH

Pursuant to the MSA the Pacific Fisheries Management Council (PFMC) has designated EFH for federally-managed fisheries within the waters of Washington, Oregon, and California. Designated EFH for groundfish and coastal pelagic species encompasses all waters from the mean high water line, and upriver extent of saltwater intrusion in river mouths, along the coasts of Washington, Oregon and California, seaward to the boundary of the U.S. exclusive economic zone (370.4 km)(PFMC 1998a, 1998b). Freshwater EFH for Pacific salmon includes all those streams, lakes, ponds, wetlands, and other water bodies currently, or historically accessible to salmon in Washington, Oregon, Idaho, and California, except areas upstream of certain impassable artificial barriers (as identified by the PFMC 1999), and longstanding, naturally-impassable barriers (*i.e.*, natural waterfalls in existence for several hundred years) (PFMC 1999). In estuarine and marine areas, designated salmon EFH extends from the nearshore and tidal submerged environments within state territorial waters out to the full extent of the exclusive economic zone (370.4 km) offshore of Washington, Oregon, and California north of Point Conception to the Canadian border (PFMC 1999).

Detailed descriptions and identifications of EFH are contained in the fishery management plans for groundfish (PFMC 1998a), coastal pelagic species (PFMC 1998b), and Pacific salmon (PFMC 1999). Casillas *et al.* (1998) provides additional detail on the groundfish EFH habitat complexes. Assessment of the potential adverse effects to these species' EFH from the proposed action is based, in part, on these descriptions and on information provided by the COE.

3.3 Proposed Actions

The proposed actions and action areas are detailed above in section 1. The action area includes habitats that have been designated as EFH for chinook and coho salmon.

3.4 Effects of Proposed Action

As described in detail in section 2.1.5 of this Opinion, the proposed action may result in short- and long-term adverse effects to a variety of habitat parameters for salmonids.

3.5 Conclusion

NOAA Fisheries concludes that the proposed action would adversely affect EFH for coho and chinook salmon.

3.6 EFH Conservation Recommendations

Pursuant to section 305(b)(4)(A) of the MSA, NOAA Fisheries is required to provide EFH conservation recommendations to Federal agencies regarding actions which may adversely affect EFH. The terms and conditions outlined in section 2.2.3 are applicable to designated EFH for chinook and coho salmon and address these adverse effects. Consequently, NOAA Fisheries incorporates them here as EFH conservation recommendations.

3.7 Statutory Response Requirement

Pursuant to the MSA (§305(b)(4)(B)) and 50 CFR 600.920(j), Federal agencies are required to provide a detailed written response to NOAA Fisheries' EFH conservation recommendations within 30 days of receipt of these recommendations. The response must include a description of measures proposed to avoid, mitigate, or offset the adverse impacts of the activity on EFH. In the case of a response that is inconsistent with the EFH conservation recommendations, the response must explain the reasons for not following the recommendations, including the scientific justification for any disagreements over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate, or offset such effects.

3.8 Supplemental Consultation

The COE must reinitiate EFH consultation with NOAA Fisheries if the proposed action is substantially revised in a manner that may adversely affect EFH, or if new information becomes available that affects the basis for NOAA Fisheries' EFH conservation recommendations (50 CFR 600.920(k)).

4. LITERATURE CITED

Abbott, R. and E. Bing-Sawyer. 2002. Assessment of pile driving impacts on the Sacramento blackfish (*Othodon microlepidotus*). Draft report prepared for Caltrans District 4. October 10, 2002.

Ainley, D.G. 1984. Cormorants Family Phalacrocoracidae. Pages 92- 101 *In:* D. Haley ed. Seabirds of the eastern North Pacific and Arctic waters. Pacific Search Press, Seattle. 214 p.

Beamesderfer, R.C. and B.E. Rieman. 1991. Abundance and Distribution of Northern Squawfish, Walleyes, and Smallmouth Bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:439-447.

Bell, M.C. 1991. Fisheries handbook of Engineering requirements and biological criteria. Fish Passage Development and Evaluation Program. U.S. Army Corps of Engineers. North Pacific Division.

Bevelhimer, M.S. 1996. Relative importance of temperature, food, and physical structure to habitat choice by smallmouth bass in laboratory experiments. Trans. Am. Fish. Soc. 125:274-283.

Birtwell, I. K., G. F. Hartman, B. Anderson, D. J. McLeay, and J. G. Malick. 1984. "A Brief Investigation of Arctic Grayling (Thymallus arcticus) and Aquatic Invertebrates in the Minto Creek Drainage, Mayo, Yukon Territory: An Area Subjected to Placer Mining." Canadian Technical Report of Fisheries and Aquatic Sciences 1287.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 *In:* W.R. Meehan, ed. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society Special Publication 19:83-138.

Blackwell, B.F., W.B. Krohn, N.R. Dube and A.J. Godin. 1997. Spring prey use by double-crested cormorants on the Penobscot River, Maine, USA. Colonial Waterbirds 20(1):77-86.

Bottom, D. L., K. K. Jones, and M. J. Herring. 1984. Fishes of the Columbia River estuary. Columbia River Estuary Data Development Program. 113 p.

Booth, D.B. 1991. Urbanization and the natural drainage system: impacts, solutions, and prognoses. The Northwest Environmental Journal 7:93-118.

Booth, D.B. and C.R. Jackson. 1997. Urbanization of aquatic systems: degradation thresholds, stormwater detection, and the limits of mitigation. Am. Wat. Resour. Assoc. 33:1077-1090.

BRT (Biological Review Team). 1997. Status review update for West Coast steelhead from Washington, Idaho, Oregon, and California. National Marine Fisheries Service, West Coast Steelhead BRT, Portland, Oregon.

Bugert, R., P. LaRiviere, D. Marbach, S. Martin, L. Ross, and D. Geist. 1990. 1989 Annual Report of Lower Snake River Compensation Plan, Salmon Hatchery Evaluation Program, to U.S. Fish and Wildlife Service (Cooperative Agreement 14-16-0001-89525).

Burgner, R. L. 1991. Life history of sockeye salmon (*Oncorhynchus nerka*). Pages 1-117 *in* C. Groot, and L. Margolis, editors. 1991. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver.

Busack, C. 1991. Genetic evaluation of the Lyons Ferry Hatchery stock and wild Snake River fall chinook. Washington Department of Fisheries, Report to ESA Administrative Record for Fall Chinook Salmon, Olympia.

Busby, P., S. Grabowski, R. Iwamoto, C. Mahnken, G. Matthews, M. Schiewe, T. Wainwright, R. Waples, J. Williams, C. Wingert, and R. Reisenbichler. 1995. Review of the status of steelhead (*Oncorhynchus mykiss*) from Washington, Idaho, Oregon, and California under the U.S. Endangered Species Act.

Busby, P. J., T. C. Wainwright, G. J. Bryant, L. J. Lierheimer, R. S. Waples, F. W. Waknitz, and I. V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-27.

Busby, P., and 10 co-authors. 1999. Updated status of the review of the Upper Willamette River and Middle Columbia River ESUs of steelhead *(Oncorhynchus mykis*s). National Marine Fisheries Service, Northwest Fisheries Science Center, West Coast Biological Review Team, Seattle, Washington.

Caltrans. 2001. Fisheries Impact Assessment, Pile Installation Demonstration Project for the San Francisco - Oakland Bay Bridge, East Span Seismic Safety Project, August 2001. 9 pp.

Campbell, K.P. 1979. Predation principles in large rivers: A review. Pages 181-191 *In:* R.H. Stroud and H. Clepper, editors. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington D.C.

Cardwell, R.D., M.I. Carr, E.W. Sanborn. 1980a. Water quality and flushing of five Puget Sound marinas. Technical Report No. 56. Washington Department of Fisheries Research and Development. Olympia, Washington. 77p.

Cardwell, R.D., S.J. Olsen, M.I. Carr, E.W. Sanborn. 1980b. Biotic, water quality and hydraulic characteristics of Skyline Marina in 1978. Technical Report No. 54. Washington Department of Fisheries Research and Development. Olympia, Washington. 103p.

Carlson, T., G. Ploskey, R.L. Johnson, R.P. Mueller and M.A. Weiland. 2001. Observations of the behavior and distribution of fish in relation to the Columbia River navigation channel and channel maintenance activities. Review draft report to the Portland District Corps of Engineers prepared by Pacific Northwest National Laboratory, Richland, Washington. 35p.

Carrasquero, J. 2001. Overwater structures: Freshwater issues. White paper submitted to Washington Department of Fish and Wildlife, Washington Department of Ecology and Washington Department of Transportation. Olympia, Washington.

Casillas, E., L. Crockett, Y. deReynier, J. Glock, M. Helvey, B. Meyer, C. Schmitt, M. Yoklavich, A. Bailey, B. Chao, B. Johnson and T. Pepperell. 1988. Essential Fish Habitat West Coast Groundfish Appendix. National Marine Fisheries Service, Montlake, Washington.

CBFWA (Columbia Basin Fish and Wildlife Authority). 1990. Snake River subbasin (mainstem from mouth to Hells Canyon Dam) salmon and steelhead production plan. CBFWA, Northwest Power Planning Council, Portland, Oregon.

Chapman, D., A. Giorgi, M. Hill, A. Maule, S. McCutcheon, D. Park, W. Platts, K. Prat, J. Seeb, L. Seeb, and others. 1991. Status of Snake River chinook salmon. Don Chapman Consultants, Inc., Boise, Idaho, for Pacific Northwest Utilities Conference Committee.

Chapman, D., C. Pevan, T. Hillman, A. Giorgi, and F. Utter. 1994. Status of summer steelhead in the mid-Columbia River. Don Chapman Consultants, Inc., Boise, Idaho.

Chapman, D., C. Peven, A. Giorgi, T. Hillman, and F. Utter. 1995. Status of spring chinook salmon in the mid-Columbia River. Don Chapman Consultants, Inc., Boise, Idaho.

Chilcote, M. W. 1997. Conservation status of steelhead in Oregon. Oregon Department of Fish and Wildlife, Draft Report, Portland. (September 9)

Christopherson, A. and J. Wilson, 2002. Technical Letter Report Regarding the San Francisco-Oakland Bay Bridge East Span Project Noise Energy Attenuation Mitigation. Peratrovich, Nottingham & Drage, Inc. Anchorage, Alaska. 27 pp.

Coble, D.W. 1975. Smallmouth bass. Pages 21-33 *In:* H. Clepper, editor. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

COE (US Army Corps of Engineers). 1977. Nehalem Wetlands Review: A Comprehensive Assessment of the Nehalem Bay and River (Oregon). U.S. Army Engineer District, Portland, Oregon. [Page count unknown].

Colle, D.E., R.L. Cailteux, and J.V. Shireman. 1989. Distribution of Florida largemouth bass in a lake after elimination of all submersed aquatic vegetation. N. Am. Journal of Fish. Mgmt. 9:213-218.

Collis, K., R.E. Beaty and B.R. Crain. 1995. Changes in Catch Rate and Diet of Northern Squawfish Associated With the Release of Hatchery-Reared Juvenile Salmonids in a Columbia River Reservoir. North American Journal of Fisheries Management 15:346-357.

Cooney, T. D. 2000. UCR steelhead and spring chinook salmon quantitative analysis report. Part 1: run reconstructions and preliminary assessment of extinction risk. Technical Review Draft. National Marine Fisheries Service, Hydro Program, Portland, Oregon.

Dawley, E.M., R.D. Ledgerwood, T.H. Blahm, C.W. Sims, J.T. Durkin, R.A. Kirn, A.E. Rankis, G.E. Monan and F.J. Ossiander. 1986. Migrational Characteristics, Biological Observations, and Relative Survival of Juvenile Salmonids Entering the Columbia River Estuary. Final Report of Research. Bonneville Power Administration Contract DE-AI79-84BP39652. Project No. 81-102. 256 p.

Derby, C.E. and J.R. Lovvorn. 1997. Predation on fish by cormorants and pelicans in a cold-water river: a field and modeling study. Can. J. Fish. Aquat. Soc. 54:1480-1493.

DeVore, P. W., L. T. Brooke, and W. A. Swenson. 1980. "The Effects of Red Clay Turbidity and Sedimentation on Aquatic Life In the Nemadji River System. Impact of Nonpoint Pollution Control on Western Lake Superior." S. C. Andrews, R. G. Christensen, and C. D. Wilson. Washington, D.C., U.S. Environmental Protection Agency. EPA Report 905/9-79-002-B.

Dolat, S.W. 1997. Acoustic measurements during the Baldwin Bridge demolition (final, dated March 14, 1997). Prepared for White Oak Construction by Sonalysts, Inc, Waterford, CT.. 34 p. + appendices.Enger et al. 1992.

Duffy, D.C. 1995. Why is the double-crested cormorant a problem? Insights from cormorant ecology and human sociology. Pages 25-32 *In:* The Double-crested Cormorant: biology, conservation and management (D.N. Nettleship and D.C. Duffy, eds.) Colonial Waterbirds 18 (Special Publication 1).

Dunsmoor, L.K., D.H. Bennett, and J.A. Chandler. 1991. Prey selectivity and growth of a planktivorous population of smallmouth bass in an Idaho reservoir. Pages 14-23 *In:* D.C. Jackson (ed) The First International Smallmouth Bass Symposium. Southern Division American Fisheries Society. Bethesda, Maryland.

Edwards, E.A., G. Gebhart and O.E. Maughan. 1983. Habitat suitablity information: smallmouth bass. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.36 47 p.

Evermann, B. W. 1895. A preliminary report upon salmon investigations in Idaho in 1894. U.S. Fish Commission Bulletin 15:253-284.

Feist, B. E., J. J. Anderson, and R. Miyamoto. 1996. Potential impacts of pile driving on juvenile pink (*Oncorhynchus gorbuscha*) and chum (*O. keta*) salmon behavior and distribution. Report No. FRI-UW-9603. Fisheries Research Institute, School of Fisheries, University of Washington. Seattle, Washington.

Franklin, J. F., and C. T. Dyrness. 1973. Natural vegetation of Oregon and Washington. U.S. Department of Agriculture, Pacific Northwest Forest and Range Experiment Station, USDA Forest Service General Technical Report PNW-8, Portland, Oregon.

Fulton, L. A. 1968. Spawning areas and abundance of chinook salmon, *Oncorhynchus tshawytsch*a, in the Columbia River basin – past and present. U.S. Fish and Wildlife Service, Special Scientific Report, Fisheries 571:26.

Funk, J.L. 1975. Structure of fish communities in streams which contain bass. Pages 140-153 *In:* H. Clepper, editor. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Gerking, S.D. 1994. Feeding Ecology of Fish. Academic Press Inc., San Diego, CA. 416 p.

Glasby, T.M. 1999. Effects of shading on subtidal epibiotic assemblages. J. Exp. Mar. Biol. Ecol. 234 (1999) 275-290.

Gray, G.A. and D.W. Rondorf. 1986. Predation on juvenile salmonids in Columbia Basin reservoirs. Pages 178-185 *In:* G.E. hall and M.J. Van Den Avle eds. Reservoir Fisheries Management Strategies for the 80's. Southern Division American Fisheries Society, Bethesda, Maryland.

Gregory, R.S. 1993. Effect of turbidity on the predator avoidance behavior of juvenile chinook salmon (Oncorhynchus tshawytcha). Canadian J. Fish. Aquatic Sciences 50:241-246.

Gregory, R. S., and C. D. Levings. 1998. "Turbidity Reduces Predation on Migrating Juvenile Pacific Salmon." Transactions of the American Fisheries Society 127: 275-285.

Gustafson, R. G., T. C. Wainwright, G. A. Winans, F. W. Waknitz, L. T. Parker, and R. S. Waples. 1997. Status review of sockeye salmon from Washington and Oregon. National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-33, Seattle, Washington.

Harrison, C.S. 1984. Terns Family Laridae Pages 146-160 *In:* D. Haley, D. ed. Seabirds of eastern North Pacific and Arctic waters. Pacific Search Press. Seattle. 214 p.

Harrison, P. 1983. Seabirds: an Identification Guide. Houghton Mifflin Company. Boston. 448 pp.

Hassemer, P. F. 1992. Run composition of the 1991-92 run-year Snake River steelhead measured at Lower Granite Dam. Idaho Fish and Game, Boise, to National Oceanic and Atmospheric Administration (Award NA90AA-D-IJ718).

Healey, M. C. 1983. Coastwide distribution and ocean migration patterns of stream- and ocean-type chinook salmon, *Oncorhynchus tshawytsch*a. Canadian Field-Naturalist 97:427-433.

Healey, M. C. 1991. Life history of chinook salmon (*Oncorhynchus tshawytscha*). Pages 311-393 *in* C. Groot, and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver.

Heidinger, R.C. 1975. Life history and biology of the largemouth bass. Pages 11-20 *In:* H. Clepper, editor. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Heiser, D.W. and E.L. Finn Jr. 1970. Observations of juvenile chum and pink salmon in marina and bulkheaded areas. Washington Department of Fisheries Management and Research Division. 28p.

Helfman, G.S. 1981. The advantage to fishes of hovering in shade. Copeia. 1981(2):392-400.

Hobson, E. S. 1979. Interactions between piscivorous fishes and their prey. Pages 231-242 *in* R. H. Stroud and H. Clepper, editors. Predator-Prey Systems in Fisheries Management. Sport Fishing Institute, Washington, D.C.

Hoffman, R.S., P.D. Capel, and S.J. Larson. 2000. Comparison of pesticides in eight U.S. urban streams. Environmental Toxicology and Chemistry. 19:2249-58.

Howell, P., K. Jones, D. Scarnecchia, L. LaVoy, W. Knedra, and D. Orrmann. 1985. Stock Assessment of Columbia River Anadromous Salmonids (Project 83-335, 2 volumes), Final Report to Bonneville Power Administration, Portland, Oregon.

Howick, G. L. and W.J. O'Brien. 1983. Piscivorous feeding behavior of largemouth bass: an experimental analysis. Trans. Am. Fish. Soc. 112:508-516.

Irving, J. S., and T. C. Bjornn. 1981. Status of Snake River fall chinook salmon in relation to the Endangered Species Act. Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow, for U.S. Fish and Wildlife Service.

Johnson, L. 2000. An analysis in support of sediment quality thresholds for polycyclic aromatic hydrocarbons (PAHs) to protect estuarine fish. White Paper from National Marine Fisheries Service , Northwest Fisheries Science Center, Seattle, Washington. 29 p.

Johnson, L., S.Y. Sol, G.M. Ylitalo, T. Hom, B. French, O.P. Olson, and T.K. Collier. 1999. Reproductive injury in English sole (*Pleuronectes vetulus*) from the Hylebos Waterway, Commencement Bay, Washington. Journal of Aquatic Ecosystem Stress and Recovery. 6:289-310.

Johnson, O. W., W. S. Grant, R. G. Cope, K. Neely, F. W. Waknitz, and R. S. Waples. 1997. Status review of chum salmon from Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-32, 280 p.

Jackson, P. L. 1993. Climate. Pages 48-57 *in* P. L. Jackson and A. J. Kimerling, editors. Atlas of the Pacific Northwest. Oregon State University Press, Corvallis.

Kahler, T., M. Grassley and D. Beauchamp. 2000. A summary of the effects of bulkheads, piers, and other artificial structures and shorezone development on ESA-listed salmonids in lakes. Final Report to the City of Bellevue, Washington. 74 p.

Keevin, T.M.. 1998. A review of natural resource agency recommendations for mitigating the impacts of underwater blasting. Rev. Fish. Sci. 6(4):281-313.

Knudsen, F.R., C.B. Schreck, S.M. Knapp, P.S. Enger, and O. Sand. 1997. Infrasound produces flight and avoidance responses in Pacific juvenile salmonids. Journal of Fish Biology, 51:824-829.

Krohn, W.B., R.B. Allen, J.R. Moring and A.E. Hutchinson. 1995. Double-crested cormorants in New England; population and management histories. Pages 99-109 In: The Double-crested Cormorant: biology, conservation and management (D.N. Nettleship and D.C. Duffy, eds.) Colonial Waterbirds 18 (Special Publication 1).

Larkin, P.A. 1979. Predator-prey relations in fishes: an overview of the theory. Pages 13-22 In: R.H. Stroud and H. Clepper, editors. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington D.C.

Lloyd, D. S. 1987. Turbidity as a Water Quality Standard for Salmonid Habitats in Alaska. North American Journal of Fisheries Management 7:34-45.

Lloyd, D. S., J. P. Koenings, and J. D. LaPerriere. 1987. "Effects of Turbidity in Fresh Waters of Alaska." North American Journal of Fisheries Management 7: 18-33.

Longmuir, C., and T. Lively. 2001. Bubble curtain systems for use during marine pile driving. Report by Fraser River Pile & Dredge Ltd., New Westminster, British.Columbia. 9 pp.

Lucchetti, G. and R. Fuerstenberg. 1993. Management of coho salmon habitat in urbanizing landscapes of King County, Washington, USA. Pages 308-317 in Proceedings of the Coho Salmon Workshop. Canadian Department of Fisheries and Oceans, Habitat Management Sector, Policy and Information Unit, Vancouver, British Columbia.

Matthews, G. M. and R. S. Waples. 1991. Status review for Snake River spring and summer chinook salmon. U.S. Department of Commerce, NOAA Technical Memo. NMFS-F/NWC-200.

McCammon, G.W. and C. von Geldern Jr. 1979. Predator-prey systems in large reservoirs. Pages 431-442 *In:* R.H. Stroud and H. Clepper, editors. Predator-prey systems in fisheries management. Sport Fishing Institute, Washington D.C.

McClure, M., B. Sanderson, E. Holmes, C. Jordan, P. Kareiva, and P. Levin. 2000a. A standardized quantitative analysis of the risks faced by salmonids in the Columbia River basin. National Marine Fisheries Service, Northwest Fisheries Science Center, Cumulative Risk Initiative, Draft Report, Seattle, Washington. April 7.

McClure, B. Sanderson, E. Holmes, C. Jordan, P. Kareiva, and P. Levin. 2000b. Revised Appendix B of standardized quantitative analysis of the risks faced by salmonids in the Columbia River basin. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington. September.

Mesing, C.L. and A.M. Wicker. 1986. Home range, spawning migrations, and homing of radio-tagged Florida largemouth bass in two central Florida lakes. Trans. Am. Fish. Soc. 115:286-295.

Metcalfe, N. B., S. K. Valdimarsson and N. H. C. Fraser. 1997. Habitat profitability and choice in a sit-and-wait predator: juvenile salmon prefer slower currents on darker nights. Journal of Animal Ecology 66:866-875.

Miller, R.J. 1975. Comparative behavior of centrarchid bass. Pages 85-94 *In:* H. Clepper, editor. Black bass biology and management. Sport Fishing Institute, Washington, D.C.

Mueller, G. 1980. Effects of recreational river traffic on nest defense by longear sunfish. Trans. Am. Fish. Soc. 109: 248-251.

Mullan, J. W., A. Rockhold, and C. R. Chrisman. 1992. Life histories and precocity of chinook salmon in the mid-Columbia River. Progressive Fish-Culturist 54:25-28.

Myers, J. M., R. G. Kope, G. J. Bryant, D. Teel, L. J. Lierheimer, T. C. Wainwright, W. S. Grant, F. W. Waknitz, K. Neely, S. T. Lindley, and R. S. Waples. 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memo. NMFS-NWFSC-35.

National Research Council. 1996. Upstream—Salmon and Society in the Pacific Northwest. National Academy Press, Washington, D.C.

Nedwell, J., and B. Edwards. 2002. Measurements of underwater noise in the Arun River during piling at County Wharf, Littlehampton. Report by Subacoustech, Ltd to David Wilson Homes, Ltd.

Newcombe, C. P., and D. D. MacDonald. 1991. "Effects of Suspended Sediments on Aquatic Ecosystems." North American Journal of Fisheries Management 11: 72-82.

Nickelson, T. E., J. W. Nicholas, A. M. McGie, R. B. Lindsay, D. L. Bottom, R. J. Kaiser, and S. E. Jacobs. 1992. Status of anadromous salmonids in Oregon coastal basins. Oregon Department of Fish and Wildlife, Research Development Section and Ocean Salmon Management. Portland, Oregon.

NMFS (National Marine Fisheries Service). 1995. Proposed recovery plan for Snake River salmon. National Marine Fisheries Service, Portland, Oregon. (March 1995)

NMFS (National Marine Fisheries Service). 1997a. Biological requirements and status under 1996 environmental baseline: Umpqua River cutthroat trout, Oregon Coast coho salmon, Oregon Coast steelhead, Southern Oregon/Northern California coho salmon Klamath Mountain Province steelhead, Lower Columbia steelhead and chum salmon. National Marine Fisheries Services, Northwest Region, Seattle, Washington.

NMFS (National Marine Fisheries Services) 1997b. Coastal coho factors for decline and protective efforts in Oregon. National Marine Fisheries Services, Northwest Region, Habitat Conservation Program, Portland, Oregon.

NMFS (National Marine Fisheries Service). 1999. Biological opinion on artificial propagation in the Columbia River basin – incidental take of listed salmon and steelhead from Federal and non- Federal hatchery programs that collect, rear, and release unlisted fish species. NOAA Fisheries, Sustainable Fisheries Division, Portland, Oregon. (March 29, 1999)

NMFS (National Marine Fisheries Service). 2000. Biological Opinion on Reinitiation of Consultation on Operation of the Federal Columbia River Power System, Including the Juvenile Fish Transportation Program, and 19 Bureau of Reclamation Projects in the Columbia Basin. NOAA Fisheries, Hydro Division, Portland, Oregon.

NMFS (National Marine Fisheries Service). 2002. Biological Opinion on the Columbia River Federal Navigation Channel Improvements Project. NOAA Fisheries, Northwest Region, Habitat Conservation Division, Portland, Oregon. (May 20, 2002)

Nordstrom, K.F. 1989. Erosion control strategies for bay and estuarine beaches. Coastal Management 17:25-35.

NWPPC (Northwest Power Planning Council). 1989. Snake River subbasin salmon and steelhead plan. Northwest Power Planning Council, Portland, Oregon.

ODFW (Oregon Department of Fish and Wildlife). 1998a. Memorandum re: harvest rates for Willamette spring chinooks, to J. Martin from S. Sharr, ODFW, Portland. (September 30)

ODFW (Oregon Department of Fish and Wildlife). 1998b. Oregon wild fish management policy. Oregon Department of Fish and Wildlife, Portland, Oregon.

ODFW (Oregon Department of Fish and Wildlife). 2000. Guidelines for timing of in-water work to protect fish and wildlife resources. Oregon Department of Fish and Wildlife, Portland, Oregon. 12 p. (June 2000)

ODFW and WDFW (Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife). 1995. Status report, Columbia River fish runs and fisheries, 1938-94. Oregon Department of Fish and Wildlife, Portland, and Washington Department of Fish and Wildlife, Olympia.

ODFW and WDFW (Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife). 1998. Status Report Columbia River Fish Runs and Fisheries, 1938-1997. Oregon Department of Fish and Wildlife, Portland, Oregon.

Omernick, J. M. 1977. Nonpoint source stream nutrient level relationships: A nationwide study. U.S. EPA, Ecological Research Series Rep. EPA-600/3-77-105.

Palmisano, J.F. 1997. Oregon's Umpqua sea-run cutthroat trout: review of natural and human-caused factors of decline. Pages 103-118 *In:* J.D. Hall, P.A. Bisson, and R.E. Gresswell, editors. Sea-run cutthroat trout: biology, management, and future conservation. Oregon Chapter, American Fisheries Society, Corvallis.

Parente, W.D. and J.G. Smith. 1981. Columbia River Backwater Study Phase II. U.S. Dept of Interior. Fisheries Assistance Office. Vancouver, Washington. 87 pp.

Paul, Michael J. and Judy L. Meyer. 2001. Streams in the Urban Landscape. Annual Review Ecol. Syst. 32:333-365.

Pentec Environmental. 2003. Mukilteo Public Access Dock Pile Driving – Air Bubble Curtain and Acoustic Monitoring, Mukilteo, Washington. 18 p. + Figs. and Appendices .

Petersen, C.J., D.B. Jepsen, R.D. Nelle, R.S. Shively, R.A. Tabor, T.P. Poe. 1990. System-Wide Significance of Predation on Juvenile Salmonids in Columbia and Snake River Reservoirs. Annual Report of Research. Bonneville Power Administration Contract DE-AI79-90BP07096. Project No. 90-078. 53 pp.

Petersen, J.M. and D.M. Gadomski. 1994. Light-Mediated Predation by Northern Squawfish on Juvenile Chinook Salmon. Journal of Fish Biology 45 (supplement A), 227-242.

Pflug, D.E. and G.B. Pauley. 1984. Biology of Smallmouth Bass (*Micropterus dolomieui*) in Lake Sammamish, Washington. Northwest Science 58(2):119-130.

PFMC (Pacific Fishery Management Council), 1998a. Final Environmental Assessment/Regulatory Review for Amendment 11 to the Pacific Coast Groundfish Fishery Management Plan. October 1998.

PFMC (Pacific Fishery Management Council), 1998b. The Coastal Pelagic Species Fishery Management Plan: Amendment 8. Portland, Oregon.

PFMC (Pacific Fishery Management Council). 1999. Amendment 14 to the Pacific Coast Salmon Plan. Appendix A: Description and Identification of Essential Fish Habitat, Adverse Impacts and Recommended Conservation Measures for Salmon. Portland, Oregon.

Phillips, S.H. 1990. A guide to the construction of freshwater artificial reefs. Sportfishing Institute. Washington D.C. 24 pp.

Pitt, R. and M. Bozeman. 1980. Water quality and biological effects of urban runoff on Coyote Creek. Phase I - Preliminary survey. U.S. EPA Environmental Protection Technology Series Rep. EPA-600/2-80-104.

Poe, T.P, H.C. Hansel, S. Vigg, D.E. Palmer, and L.A. Prendergast. 1991. Feeding of Predaceous Fishes on Out-Migrating Juvenile Salmonids in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:405-420.

Poston. T. 2001. Treated wood issues associated with overwater structures in marine and freshwater environments. Prepared for the Washington Departments of Fish and Wildlife, Ecology, and Transportation. Olympia, Washington.

Raibley, P.T., K.S. Irons, T.M. O'Hara, and K.D. Blodgett. 1997. Winter habitats used by largemouth bass in the Illinois River, a large river-floodplain ecosystem. N. Am. J. Fish. Mgmt. 17:401-412.

Redding, J. M., C. B. Schreck, and F. H. Everest. 1987. Physiological Effects on Coho Salmon and Steelhead of Exposure to Suspended Solids. Transactions of the American Fisheries Society 116: 737-744.

Reyff, J.A. 2003. Underwater sound levels associated with seismic retrofit construction of the Richmond-San Rafael Bridge. Document in support of Biological Assessment for the Richmond-San Rafael Bridge Seismic Safety Project. January, 31, 2003. 18 pp.

Reyff, J.A and P. Donovan. 2003. Benicia-Martinez Bridge Bubble Curtain Test - Underwater Sound Measurement Data. Memo to Caltrans dated January 31, 2003. 3 pp.

Rieman, B.E. and R.C. Beamesderfer. 1991. Estimated Loss of Juvenile Salmonids to Predation by Northern Squawfish, Walleyes, and Smallmouth Bass in John Day Reservoir, Columbia River. Transactions of the American Fisheries Society 120:448-458.

Risser, P.G. (Chair, State of the Environment Science Panel). 2000. Oregon State of the Environment Report 2000. Oregon Progress Board, Salem, Oregon.

Rogers, P.H. and M. Cox. 1988. Underwater sound as a biological stimulus. pp. 131-149 *in*: Sensory biology of aquatic animals. Atema, J, R.R. Fay, A.N. Popper and W.N. Tavolga (eds.). Springer-Verlag. New York.

Salo, E. O. 1991. Life history of chum salmon (*Oncorhynchus keta*). Pages 231-309 *in* C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver.

Sand, O., P.S. Enger, H.E. Karlsen, F. Knudsen, T. Kvernstuen. 2000. Avoidance responses to infrasound in downstream migrating European silver eels, Anguilla anguilla. Environmental Biology of Fishes, 57:327-336.

Sandercock, F. K. 1991. Life history of coho salmon (*Oncorhynchus kisutch*). Pages 395-445 *in* C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver.

Scannell, P.O. 1988. Effects of Elevated Sediment Levels from Placer Mining on Survival and Behavior of Immature Arctic Grayling. Alaska Cooperative Fishery Unit, University of Alaska. Unit Contribution 27.

Schaeffer, L. 1992. Avian predators at ODFW hatcheries: their identification and control. Oregon Department of Fish and Wildlife Information Reports Number 92-1. 19 p.

Scholtz, N.C., N.K. Truelore, B.L. French, B.A. Berejikian, T.P. Quinn, E. Casillas, and T.K. Collier. 2000. Diazinon disrupts anti-predator and homing behaviors in Chinook salmon (O. tshawytscha). Can.J.Fish.Aquat.Sci. 57:1911-1918.

Servizi, J. A., and Martens, D. W. 1991. Effects of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon. Canadian Journal of Fisheries and Aquatic Sciences 49:1389-1395.

Sigler, J. W., T. C. Bjornn, and F. H. Everest. 1984. "Effects of Chronic Turbidity on Density and Growth of Steelheads and Coho Salmon." Transactions of the American Fisheries Society 113: 142-150. 1984.

Simmons, D. 2000. Excel spreadsheet: Snake River fall chinook, annual adult equivalent exploitation rates (AEQ Catch/[AEQ Catch + Escapement]) adjusted to joint staff estimates of ocean escapement. E-mail. National Marine Fisheries Service, Sustainable Fisheries Division, Seattle, Washington.

Spence, B. C., G. A. Lomnicky, R. M. Hughes, and R. P. Novitzki. 1996. An ecosystem approach to salmonid conservation. ManTech Environmental Research Services, Inc., Corvallis, Oregon, to National Marine Fisheries Service, Habitat Conservation Division, Portland, Oregon (Project TR-4501-96-6057).

Stehr, C.M., D.W. Brown, T. Hom, B.F. Anulacion, W.L. Reichert, and T.K. Collier. 2000. Exposure of juvenile chinook and chum salmon to chemical contaminants in the Hylebos Waterway of Commencement Bay, Tacoma, Washington. Journal of Aquatic Ecosystem Stress and Recovery. 7:215-227.

Stotz, T. and J. Colby. 2001. January 2001 dive report for Mukilteo wingwall replacement project. Washington State Ferries Memorandum. 5 pp. + appendices.

Stuber, R.J., J.G. Gebhart, and O.E. Maughan. 1982. Habitat suitability index models: largemouth bass. U.S. Dept. Int. Fish Wildl. Serv. FWS/OBS-82/10.16. 32 pp.

Takata, H.K. and D.L. Ward. 2000. Effects of Columbia River treaty fishing site development on predators of juvenile salmonids. Portland District Corps of Engineers Cooperative Agreement Contract W66QZK80696971. 12 pp.

Taylor, E., A. Steen, and D. Fritz. 1995. A review of environmental effects from oil spills into inland waters. Pages 1095-1115 in: Proc. Of the 18th Arctic and Marine Oil Spill Program Tech. Sem., June 14-16, Edmonton, Env. Canada.

U.S. Geological Survey (USGS). 1999a. The quality of our nation's waters-nutrients and pesticides. USGS Circular 1225.

U.S. Geological Survey (USGS). 1999b. Pesticides detected in urban streams during rainstorms and relations to retail sales of pesticides in King County, Washington. USGS Fact Sheet 097-99.

Walters, D.A., W.E. Lynch, Jr., and D.L. Johnson. 1991. How depth and interstice size of artificial structures influence fish attraction. N. Am. J. Fish. Mgmt. 11:319-329.

Wanjala, B.S., J.C. Tash, W.J. Matter and C.D. Ziebell. 1986. Food and habitat use by different sizes of largemouth bass (*Micropterus salmoides*) in Alamo Lake, Arizona. Journal of Freshwater Ecology Vol. 3(3):359-368.

Waples, R. S. 1991. Pacific salmon, Oncorhynchus spp., and the definition of "species" under the Endangered Species Act. Marine Fisheries Review 53(3):11-22.

Waples, R. S. 1999. Dispelling some myths about hatcheries. Fisheries 24(2):12-21.

Waples, R. S., O. W. Johnson, and R. P. Jones, Jr. 1991a. Status review for Snake River sockeye salmon. U.S. Department of Commerce, NOAA Technical Memo, National Marine Fisheries Service NMFS F/NWC-195.

Waples, R. S., R. P. Jones, Jr., B. R. Beckman, and G. A. Swan. 1991b. Status review for Snake River fall chinook salmon. U.S. Department of Commerce, NOAA Technical Memo. National Marine Fisheries Service F/NWC-201.

Ward, D.L. (ed). 1992. Effects of waterway development on anadromous and resident fish in Portland Harbor. Final Report of Research. Oregon Dept. of Fish and Wildlife. 48 pp.

Ward, D.L. and A.A. Nigro. 1992. Differences in Fish Assemblages Among Habitats Found in the Lower Willamette River, Oregon: Application of and Problems With Multivariate Analysis. Fisheries Research 13:119-132.

Ward, D.L., A.A. Nigro, R.A. Farr, and C.J. Knutsen. 1994. Influence of Waterway Development on Migrational Characteristics of Juvenile Salmonids in the Lower Willamette River, Oregon. North American Journal of Fisheries Management 14:362-371.

Ward, D.L., C.J. Knutsen, and R.A. Farr. 1991. Status and biology of black crappie and white crappie in the lower Willamette River near Portland, Oregon. Oregon Department of Fish and Wildlife Fish Division Information Reports Number 91-3. Portland, Oregon. 17 pp.

Warrington, P. D. 1999a. Impacts of recreational boating on the aquatic environment. http://www.nalms.org/bclss/impactsrecreationboat.htm

Warrington, P.D1999b. Impacts of outboard motors on the aquatic environment. http://www.nalms.org/bclss/impactsoutboard.htm

WDF, WDW, and WWTIT (Washington Department of Fisheries, Washington Department of Wildlife, and Western Washington Treaty Indian Tribes). 1993. Washington state salmon and steelhead stock inventory (SASSI), 1992. Washington Department of Fisheries, Washington Department of Wildlife and Western Washington Treaty Indian Tribes. Olympia.

Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho salmon from Washington, Oregon and California. National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

Whitt, C. R. 1954. The age, growth, and migration of steelhead trout in the Clearwater River, Idaho. Master's thesis. University of Idaho, Moscow.

Wilber, W.G. and J.V. Hunter. 1979. The impact of urbanization on the distribution of heavy metals in bottom sediments of the Saddle River. Water Resources Bulletin. 15:790-800.

Würsig, B., C.R. Greene, Jr., and T.A. Jefferson. 2000. Development of an air bubble curtain to reduce underwater noise from percussive piling. Marine Environmental Research 49: 19-93.